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EDITORIAL NOTES.

WE regret to announce the death of Professor Charles Lapworth, in his 78th year. Few geologists have exerted a more profound influence upon the progress of our science. His labours among the older rocks are a witness to his genius. He founded a Geological School of the first rank in the University of Birmingham, but the influence of his teaching was by no means confined to the students of that University. Many prominent geologists at home and abroad must be proud to regard themselves as his pupils. By his application of geology to various matters of economic importance he made it abundantly clear to men of business that this science was of great practical utility. His books are marked by high originality as regards both treatment and subject-matter. He was a man of singular charm, and greatly loved by all who knew him. A life of Professor Lapworth appeared in this Magazine in 1901 as one of our "Eminent Living Geologists". We hope shortly to give an appreciation of his life and work.

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OUR readers will doubtless notice the disappearance from this number of a familiar feature, namely the abstracts of papers read to the Geological Society of London. For the last few months, owing to a large influx of original papers, reviews, and correspondence, it has been difficult to afford the requisite space, and publication has often been considerably delayed. It may be taken for granted that the great majority of our readers receive these abstracts together with the discussions, which we do not reproduce, direct from the Society in due course. The abstracts have to be entirely reset in type, and it is considered that the cost of this would be better bestowed on original articles and on reviews. It is intended, however, to continue the publication of abstracts of papers read at the meetings of other societies of smaller membership, and even to enlarge this feature by the inclusion of brief summaries of papers of geological interest read to societies which are not purely geological in their scope, such as, for example, the Institution of Mining and Metallurgy. The Editors will be very glad to receive from Secretaries of local societies or from authors *short* abstracts of papers considered suitable for this section of the GEOLOGICAL MAGAZINE.

In the list of those recommended by the Council for election to the Royal Society we are glad to see the name of Dr. Robert Broom, of Griquatown, South Africa. The importance of Dr. Broom's work in anatomy and zoology is generally recognized, both in its bearings on the evolution of the higher vertebrates and in its relations to the study of South African stratigraphy. Dr. F. H. A. Marshall also, though pre-eminently a physiologist and agriculturalist, has taken much interest in the geological history of the vertebrates, and in particular of the domesticated animals, on which he has published some interesting details. But with these exceptions the list is, frankly, very disappointing. It does not contain the name of any geologist or of any representative of the allied sciences of mineralogy and geography. This is very discouraging to the workers in all these branches, now so numerous, and if this policy continues a deadlock will soon be reached, so that many eminent geologists, mineralogists, and geographers who have reached the meridian of life will see their chances of election indefinitely postponed, while for the younger generation the outlook is unpromising.

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Very different is the complexion of the similar list issued by the Royal Society of Edinburgh. This includes the names of no less than four geologists, namely Mr. E. M. Anderson, Mr. E. B. Bailey, Mr. R. G. Carruthers, all members of the Geological Survey of Great Britain, and Mr. W. R. Smellie, geologist on the staff of the Anglo-Persian Oil Company. Some of these gentlemen are valued contributors to our pages, and we are glad to avail ourselves of this opportunity to acknowledge with gratitude the support and encouragement that we have received from Scottish geologists, and especially from Mr. Bailey, during the recent crisis in the affairs of the Magazine.

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Captain W. B. R. King, O.B.E., M.A., F.G.S., of Jesus College, Cambridge, formerly of H.M. Geological Survey, and now Assistant to the Woodwardian Professor, has been elected to a Fellowship at Jesus College. We have already had occasion to refer more than once to the brilliant work carried out by Captain King as geologist on the Western Front, and we congratulate him heartily on this further distinction added by his college to his well-deserved honours.

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The Geological Society of London and the Mineralogical Society have set up a joint committee of twelve petrologists "to consider whether any standardization of British petrographic nomenclature is possible and desirable, and if so, to make recommendations with that end in view". The following six members were nominated by the Geological Society: Dr. J. S. Flett, Mr. A. Harker, Sir J. J. Harris Teall, Dr. H. H. Thomas, Mr. G. W. Tyrrell, and Professor

W. W. Watts. The nominations of the Mineralogical Society are as follows: Dr. J. W. Evans, Dr. F. H. Hatch, Dr. A. Holmes, Dr. G. T. Prior, Mr. R. H. Rastall, Mr. W. Campbell Smith. It is not yet known whether all the above nominees are willing to serve on the Committee. The first meeting of the Committee was held at 2.30 p.m. on March 16, when a preliminary discussion took place and certain resolutions were drawn up for consideration at the next meeting.

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We have been privileged to see a copy of a very interesting Report of a Commission appointed to examine the condition of the iron and steel works in Lorraine, in the occupied areas of Germany, in Belgium, and in France. Although the Report is in the main concerned with technical engineering details of the practice in the great iron and steel works of these areas, nevertheless there are to be found here and there items of information of geological interest, chiefly referring to the iron-ores of Lorraine and the coal of the Saar Basin. It is obvious that the terms of the Peace Treaty must have an enormous effect on the future of the iron and steel industries of both France and Germany. Before the War the iron-ore resources of France and Germany were estimated at 3,300,000,000 tons and 3,600,000,000 tons, or approximately equal. The relative positions at present are about 5,500,000,000 tons and 1,300,000,000 tons respectively. Thus France has now more than four times as much iron-ore as Germany, and it is expected that in the near future her annual production will rise to 42,000,000 tons, or double what it was before the War, and nearly three times as much as the British output. But at present the development of the industry is held up by the impossibility of obtaining from Germany the regular supply of Westphalian coal stipulated for in the Treaty. Saar coal alone is not satisfactory for blast-furnace coke, and requires an admixture of at least 25 per cent of Westphalian or British coking coal. The French ironmasters desire to establish a reciprocal trade with this country, exchanging Lorraine basic pig-iron for British coke, but the transport difficulty stands in the way. This may perhaps eventually be met by a system of canals. The scheme most favoured is that known as the "Canalization of the Moselle" from Thionville to Coblentz, with free navigation of the Rhine to Rotterdam, or canal from the Rhine to Antwerp. An alternative plan is for a canal from Dunkirk to the Briey ironfield. It is considered that this scheme would cause inconvenience in cutting through the thickly populated industrial districts of Northern France, and the cost would be enormous.

ORIGINAL ARTICLES.

The Pre-Glacial Valleys of Arran and Snowdon.[1]

By J. W. Gregory, F.R.S., University, Glasgow.

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Introduction.

THE history of the British Isles in the Pliocene has an important bearing on their glacial geology and on the origin of their existing geographical features. Physiographic evidence indicates that the Lower Pliocene was in Britain an epoch of depression, during which the sea covered parts of South-Eastern England, whereas the Middle and Upper Pliocene were marked by an uplift which excluded the sea from the British Isles, except in East Anglia and Western Cornwall. It is generally agreed that this uplift raised the low-lying plains that had been formed during the Lower Pliocene into plateaus from 500 to 1,400 feet above sea-level. The uplift lasted through a long period of time; and such a slowly rising land would naturally be greatly denuded by rivers. Plateaus and platforms due to the Pliocene uplift have been described by Dr. Mort for Arran and by Professor W. M. Davis for Snowdon; yet in their discussion of the present topography of those districts they attribute a very slight influence to stream erosion during the long pre-Glacial elevation.

The Island of Arran, amongst its many other attractions, offers much clear evidence on the history of this plateau and its bearing on the problem whether the Scottish valleys were made or merely moulded by glacial action. Dr. Mort has recently so attractively restated the case for the glacial origin of these valleys, that it may be advisable to summarize the evidence in favour of pre-Glacial rivers having been the more important agent in their formation. Though Dr. Mort's memoir appears to attribute to ice too large a share in the formation of the Arran valleys, it includes several such

[1] Since this paper was written, shortly after a revisit to Snowdon in September, 1915, the Pliocene plateau of Carnarvon has been described by Mr. Dewey, who demonstrates the pre-Glacial age of the Snowdon valleys: "On the Origin of some Land-forms in Caernarvonshire, North Wales": Geol. Mag., 1918, pp. 145–57, Pl. VII. The publication of the present paper has been delayed by pre-occupation with other matters and two years' absence abroad: it is issued as originally written except for a few verbal changes. I am greatly indebted to Dr. A. Scott, who during my absence kindly re-drew the sections for press.

important additions to the geographical history of Arran as to form a contribution of permanent value to the literature of Scottish physiography.

1. The Valley System of North Arran.

North Arran has a comparatively simple structure in spite of the great variety of its rocks. It consists of a nearly circular block of granite (Fig. 1) which varies from 7 to 8 miles in diameter

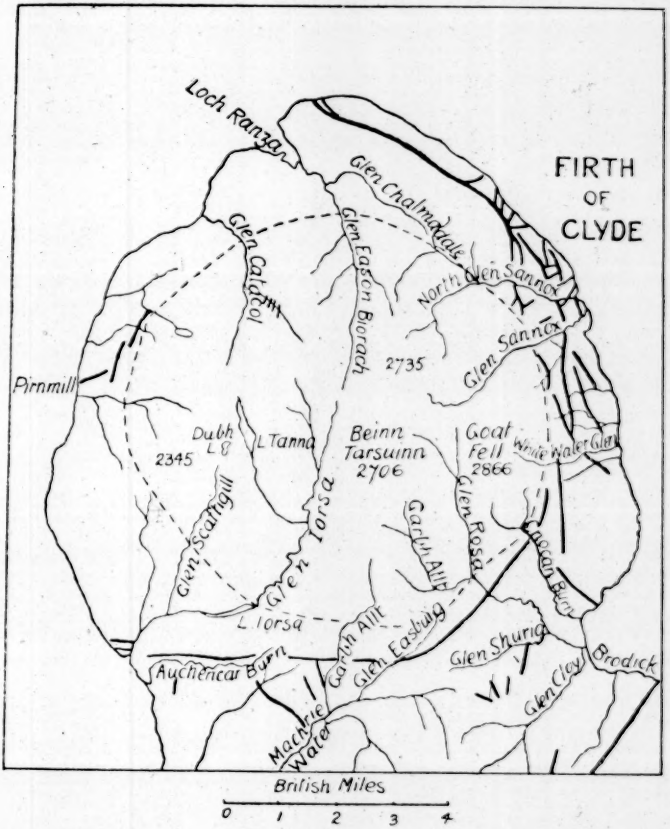

Fig. 1.—Sketch-map of North Arran, showing the faults (thick lines) and the granite (within the broken line).

and is surrounded by a girdle of metamorphic and sedimentary rocks. They formerly covered the granite as a dome from which rivers must have flowed radially in all directions. The highest mountain in Arran, Goatfell, is 2,866 feet, and three other summits rise over 2,600 feet; hence the area was apparently cut down to a plain at the height, in the granite district, of a little under 3,000

feet.[1] The date and mode of formation of that plain are uncertain; but it was probably cut when the country was lower than at present, and that plain may have been nearly at sea-level.

The history of the existing valleys begins with the elevation of this plain into a plateau. During the uplift radial streams must have flowed from the granite highlands. There are in North Arran about twenty-two radial streams in addition to the lower ends of the major valleys. These radial streams trend as follows :—

N.E. Two streams of North Glen Sannox.
E.N.E. Glen Sannox.
E. Four streams near Corrie, of which the longest is the White Water Glen.
S.E. Merkland Burn and Cnocan Burn from Goatfell.
S. The eastern Garbh Allt, from Ben Tarsuinn.
S.S.W. The western Garbh Allt from Beinn Nuis; and Auchencar Burn from S.S.W. of Beinn Tarsuinn.
S.W. Glen Scaftigill.
W. Eight burns, of which the longest is the Allt Gobhlach.
N.W. Abhainn Beag.

These radial streams are all of secondary importance. The major valleys, in which ground less than 1,000 feet in height reaches the centre of the granite mountains, run north and south. The granite dome is, in fact, dissected by three main valleys which cut across it north and south. The longest and most conspicuous of these valleys is that of Glen Iorsa and Glen Easan Biorach; it cuts across the middle of the granite mass. Further east is the valley of Glen Rosa, which is continued northward by Glen Sannox; this joint valley runs north and south for most of its length, but both its lower ends bend eastward to the sea. The third north and south valley, that of Glen Catacol and Glen Scaftigill, is on the western side of the island; its lower end bends westward to the sea, which the Scaftigill Burn reaches through the Iorsa Water. Each of these three valleys includes a large tract of ground below the level of 1,000 feet. On the floor of Glen Iorsa a band of alluvium, most of which is below the level of 250 feet, occurs in the very centre of North Arran; even the uppermost part of this alluvium is below 350 feet. Most of the floors of Glen Rosa and Glen Sannox are less than 500 feet above the sea.

In addition to the three north and south valleys there is another major valley in North Arran. It consists of Glen Chalmadale and North Glen Sannox; it crosses the island from Loch Ranza east-south-eastward to Sannox Bay and separates the plateau of Creag Ghlass Laggan (1,453 feet) from the rest of the highlands.

The valley system of North Arran may therefore be classified as follows :—

A. Minor Valleys.
    I. Radial valleys from the granite hills.
B. Major Valleys.
    II. The three north to south valleys across the granite hills.

[1] This feature was recognized and illustrated by Sir A. C. Ramsay (1841, sect. i, opposite p. 8).

III. The north-west to south-east valley across the north-east of the island between Loch Ranza and Sannox Bay.

IV. The valley which crosses from Brodick over a divide at 768 feet and separates the mountains of North Arran from the moorlands that form most of the southern part of the island.

2. Evolution of the Existing Topography.

The most striking feature of the major valleys of North Arran is their independence alike of the main slopes and geological structure. The major valleys are not radial from the mountains and they are independent of the geological structure. Thus the three north and south valleys cut right across the granite mass, and though their lower ends bend seaward this change of course appears independent of the structure of the schistose and sedimentary girdle.[1]

However greatly the valleys may have been enlarged by denudation, their plan was determined by some influence which affected the area as a whole and was independent of its structure.

In order to determine the origin of these valleys and the extent to which they are due to glacial erosion it is necessary to determine the general topography of the country at the beginning of its glaciation. That topography was the result of the geographical evolution of the island after the igneous activity of the middle Kainozoic. The next process was the planing of Arran to a gently undulating tableland, of which the surface in the Goatfell Mountains was, perhaps, 2,000 feet above sea-level. The land extended further on all sides, and the slopes were longer and gentler than they are now. During this stage Arran was part of the mainland ; and, as Dr. Mort suggests, the Chalmadale–North Sannox valley was probably initiated then by rivers that flowed south-eastward across North-Eastern Arran. The country was again uplifted, and Arran was isolated by tectonic valleys to east and west, and a series of north and south clefts parallel to these valleys cut across the granite mass of North Arran. The clefts were subsequently enlarged by denudation into the three major north and south valleys of the island.

After the second uplift the land must have remained stationary for a sufficient period, for the formation of a low plain, which was raised by a third movement into the thousand-foot platform (Fig. 2). This uplift doubtless reopened the north and south clefts,

[1] Among the valuable contributions in Dr. Mort's paper is his rejection of the view that the difference in form between the central and western mountains was due to the texture of the granite. His objections to that explanation seem convincing. The western hills were completely overridden by ice, of which the lower part would have been charged with rock debris from the smooth central peaks and would have worn down the western summits into rounded ridges. The lower part of the snow-cap over Cir Mhor and Goatfell may have been converted to ice ; but after the ice had removed the loose material it would have consisted of clean ice and have had but little abrasive power. By the time it had reached the western hills the lower layers were probably charged with rock fragments and were thus a more effective file.

and they were enlarged by denudation until their floors were but little above sea-level. During these movements the climate was becoming colder, as is shown by the disappearance from the British seas of those Lower Pliocene mollusca that are characteristic of warmer conditions. Frost action must have attacked the higher peaks and especially the slopes facing north and east; and the continual freezing and thawing of water in the joints of the granite led to the formation of corries along the margins of the snow-fields. Dr. Mort's memoir on Arran gives the first adequate description of its thousand-foot platform, which is also well developed in Ayrshire. Dr. Mort has advanced good reasons for the opinion that it was probably due in Arran to marine denudation.[1] If so, this platform is evidence of an uplift of at least 1,000 feet; and that it was several hundred feet greater than that amount is shown, as Dr. Mort remarks, by the buried valleys in South-Western Scotland. If this platform be a plain of marine denudation the uplift in Arran was not uniform. The platform varies in height from 800 to 1,200 feet around the Goatfell Mountains, and to the north-west of Brodick. It is from 700 to 1,000 feet beside the western coast from lower Glen Iorsa northwards to near Pirnmill; from 750 to 1,000 feet north of North Glen Sannox; from 500 to 750 feet in the south-western part of the island, between Blackwaterfoot and Glen Scorrodale; and between 500 or 600 feet and 900 feet in the south-eastern part of the island. That the uplift was differential agrees with the aspect of the land as seen from the steamer when approaching Brodick, as the platform slopes gently downward from the Goatfell Mountains both to south and north. That the greatest uplift occurred north of Brodick was recognized by Sir Andrew Ramsay (1841, section i, opposite p. 8), who represented the island as part of a great anticline with its axis ending on the eastern coast at North Sannox.

The uplift of the thousand-foot platform was unquestionably pre-Glacial, for deep valleys with glaciated floors, on which are well-preserved moraines, had been cut through it to the level of less than 100 feet above the sea. The effects of post-Glacial denudation on the island have been comparatively trivial; gorges, sometimes 30 feet deep, have been cut by streams through easily denuded rock. The post-Glacial period has been very short compared to that occupied by the formation of the major valleys.

In Glacial times Arran was a local glacial centre. Ice formed over the mountains of North Arran and flowed radially to the sea. Dr. Mort quotes with approval Gunn's remark that Arran had a "local icecap which shed material all round" (Gunn, 1903,

[1] Professor Davis (1909, p. 289) gives as a criterion for the distinction of marine from subaerial plains that in sea-cut plains "the border of the unreduced masses should have been a sea-cliff"; while in subaerial plains "there would presumably be a gradual transition from unreduced masses to the reduced plain". As Dr. Mort points out, the abrupt ending of the platform against the mountains favours the marine origin of this plain.

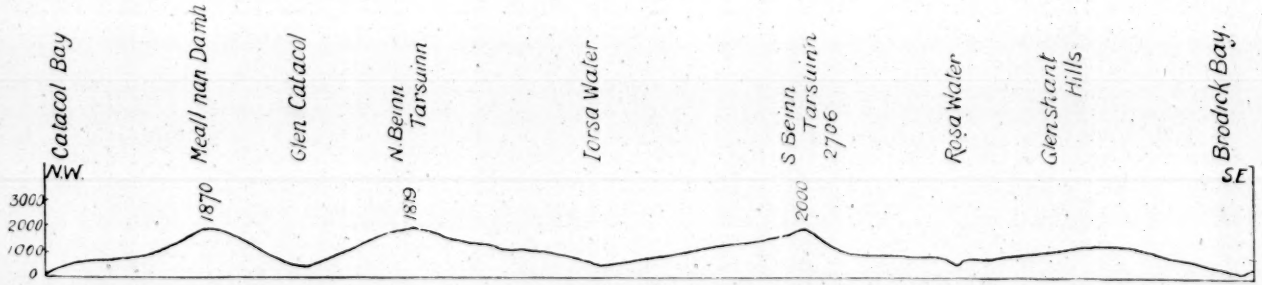

Fig 2. Horizontal scale 3/8" = 1 mile.

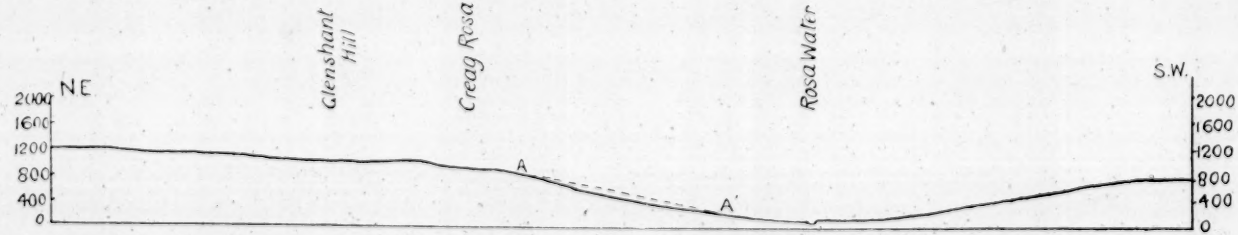

Fig 3. Length of Section 1.5 Miles

FIG. 2.—Section from Catacol Bay, through Meall nan Damh, N. Beinn Tarsuinn, Glen Iorsa, S. Beinn Tarsuinn, to Glenshant Hills, showing the range of the 1,000 ft. platform in the S.E. part of the section. Horizontal scale, 1 inch = 1 mile.

FIG. 3.—Section across Glen Rosa through the 1,000–1,200 ft. platform on Glenshant Hill, and through the ice-worn slope of Creag Rosa to Glen Rosa.

On the view that Glen Rosa had its present depth in pre-Glacial times, the rock removed from Creag Rosa during the glaciation would be that between the broken line AA' and the present surface.

pp. 132–3). "From the high ground of the interior," says Dr. Mort, "glaciers diverged, which finally joined the main streams, and moved south down the Firth" (Mort, 1914, p. 25). The flow to the north was blocked by ice from the mainland, and the chief discharge was southward. As granite erratics from Arran are rarely found in Ayrshire its ice must have been deflected to the south immediately after leaving the island by ice from the north.

If the Arran valleys had been formed by the radially flowing ice they should have been radial from the granite centre, and it has been claimed that they "run approximately from the centre in radial fashion" (Mort, 1914, p. 7). This is true of the minor valleys; but the most conspicuous feature in the arrangement of the major valleys of Arran is that they are not radial.

Dr. Mort remarks (op. cit., p. 71) that the Arran glens present features which cannot be explained by normal stream erosion; and this view is certainly correct as regards their plan, which would not have been adopted by streams flowing from the granite dome of Northern Arran unless the denudation had been guided by pre-existing lines of weakness. The same objection, however, would apply to ice erosion; for, unless guided by pre-Glacial valleys, glacial erosion should also have produced valleys radial from the high ground. The major valleys were probably determined by structural lines of weakness due to the uplift of the area. Glen Rosa and upper Glen Sannox occur along a basaltic dyke, which is the longest dyke in Arran. This dyke was forced into a north and south rift formed before the end of the igneous period. The uplift which formed the thousand-foot platform probably caused a series of north and south fractures which did not produce many faults, but rifts or bands of ruptured weakened rock (the shatter-belts of Marr). The streams naturally followed these rifts and weak bands, and thus the major valleys of North Arran were a series of three north and south valleys across the granite block. That these three valleys were tectonic in origin appears to be further indicated by their agreement with the general structural lines of the district. The general course of the eastern and western coasts has been determined by faults and fractures. Kilbrennan Sound to the west and the main Firth of Clyde to the east are probably both sunken blocks, which have been let down by north and south trough faults; and the block of North Arran was doubtless rent by north and south clefts formed by the same series of movements.

3. Tectonic Clefts and Shatter-belts.

The valleys, however, are not fault valleys, as no recognizable displacement has taken place among them. They may be simple clefts formed by the gaping of fractures in rocks undergoing tension during uplift. The necessary formation of such tension clefts has been repeatedly asserted, as e.g. by James Smith in 1862 (p. 24), by Ruskin (1856, vol. iv, p. 229, i.e. pt. v, ch. xv, p. 31), and Bailey

Willis (1893, pl. lxxv). Such tension clefts would be narrow, but would be enlarged by the streams that would flow along them.

Broader valleys would be formed where tension is relieved by a multiple instead of by a simple fracture. This multiple fracture might consist of parallel fractures connected by cross fractures, or of anastomosing branching fractures. Such multiple fractures would produce a belt of shattered rock and thus form one variety of the shatter-belts of Professor Marr. His definition (1906, p. 77; reaffirmed 1916, p. 71) attributed shatter-belts to oscillatory faults, which cause no final displacement as the rocks on both sides are restored to their original positions by the backward and forward movement. He describes these belts as many yards in width and as composed of rock "broken into a rubbly mass of angular fragments of varying size in a matrix of finer crushed material". Such belts of shattered material may also be formed by bands of rock being torn to pieces by tension cracks; and some shatter-belts of the Lake District would appear to be more easily explained as multiple anastomosing tension clefts than as faults; and the broader valleys of Arran and the major valleys of the rectilinear system around Snowdon may occur along shatter-belts due to tension during the Pliocene uplift. Shatter-belts probably often occur where they cannot be seen, for they would be seldom exposed on the floors of the valleys, and quickly obscured on the sides; and in the absence of clear exposures, shatter-belts formed as crush breccias are indistinguishable from those due to multiple tension fractures. The term shatter-belt may be conveniently used for both kinds.

4. Amount of Glacial Excavation in the Valleys.

With the increasing severity of the climate the country was occupied by glaciers, and they found an immature topography on which even limited glacial erosion would have produced conspicuous results. The ice flowing down the valleys must have pressed against the spurs, cut them back, and thus rendered the north and south valleys trough-shaped. There seems no convincing evidence that the ice materially deepened the valleys. Some of the alluvial plains may cover buried channels formed at the same time as those on the mainland; but none of the freshwater lochs of Arran have floors lower than sea-level. No known Arran valley has been excavated below the base-level of the pre-Glacial rivers. Accordingly there is no need to assume the glacial deepening of the valleys.

The amount of hard rock removed by ice in widening the valleys was not necessarily considerable. The ice doubtless wore away the spurs, some of which are now represented only by blunt gables on the hill-sides, such as Torr Breac at the bend of Glen Rosa. The smooth spurless slopes at first give the impression of extensive ice erosion. But if, as seems most probable, the three north and south valleys were formed along tension clefts made by the uplift, their original course would have been straight and the spurs on their

sides would have been short and blunt. Their pre-Glacial walls probably stood quite close to the existing walls. One of the best-known ice-worn slopes in Arran is the southern face of Creag Rosa. But a section across this slope based on the Ordnance maps (Fig. 3), even with the vertical scale magnified twice, does not give the impression of any great overdeepening. If the floor of the valley had been at its present depth in pre-Glacial times, the dotted line on the figure would indicate the approximate position of the pre-Glacial slope. The greatest thickness of rock removed by the ice would only have been about 100 feet, and this layer would have been weakened by pre-Glacial disintegration. The thickness of hard fresh rock removed would have been insignificant.

5. Garbh Allt and the Glacial Deepening of Glen Rosa.

Dr. Mort, however, holds that Glen Rosa was glacially deepened to the extent of between 500 and 800 feet, a conclusion based mainly on the hanging valley of Garbh Allt. This stream rises on the south-eastern slopes of Beinn Tarsuinn, and at first flows south-south-east parallel to Glen Rosa; at 800 feet it bends suddenly eastward, and is joined by a tributary from the west; it follows the direction of this stream and discharges to the east-north-east by a series of cascades to Glen Rosa. It comes from a hanging valley which ends 500 feet above its confluence with the Rosa Water; and Dr. Mort holds that the difference in level between the hanging valley and the Rosa Water is due to glacial deepening of at least 500 feet and perhaps of 800 feet.

The limited corrosion by the lower Garbh Allt is capable of another explanation. Dr. A. Scott suggested to me the possibility that the Garbh Allt was originally the head of the Easbuig Burn (Bishop's Glen), a tributary of the Machrie Water; and a visit to the locality showed the high probability of the suggestion. Figs. 4 and 5 show five sections across the hills to the west of Glen Rosa. Section 4A crosses the upper part of the Garbh Allt, which there flows through a valley clearly separated from the parallel valley of Glen Rosa. Section 4B crosses the middle part of the Garbh Allt, where the eastern side of the valley is inconspicuous. Section 4C is along the lower course of the Garbh Allt below the right-angled bend at 800 feet; the section is continued westward along the tributary which continues the course of the cascades of the Garbh Allt. Section 5D is along the low flat rise which separates Garbh Allt from Glen Easbuig to the south-west, and from the tributaries of Glen Shurig to the south-east. Section 5E crosses Glen Easbuig from north-west to south-east at the same distance from D as that is from Section C and as C is from B. These sections show a continuous valley which was probably the original course of the Garbh Allt when, instead of turning to the east at C, it descended from 1,114 feet in B, over the depression at a little over 1,000 feet in Section D to Glen Easbuig. The Garbh Allt has now been diverted eastward to

Glen Rosa, along the junction between the schists and the granites. The character of the falls and their rock steps show that the lower end of the Garbh Allt is along a modern channel. The fact that the stream has not cut down its bed there more deeply is due to its recent adoption of its present course, and is not evidence of the glacial deepening of Glen Rosa.

Dr. Mort also claims (pp. 57–8) that Glen Iorsa opposite Loch Nuis has been glacially deepened by from 500 to 800 feet, since the stream from that loch has made no notch in the bank of Glen Iorsa; but the loch lies on a projecting spur of the thousand-foot platform and the drainage from it is insignificant. The larger streams which join Glen Iorsa, as from Loch Tanna and the streams from both the Bens Tarsuinn, have deeply incised the sides of the main glen.

The position of Glen Diomhan as a hanging valley 200 feet above Glen Catacol is advanced by Dr. Mort (pp. 54–5) as evidence that the latter has been deepened by ice; but as Glen Catacol is one of the tectonic north and south valleys it was probably older than its tributary; and their difference in level is the natural consequence of the small Diomhan Burn not having been able to deepen its valley as quickly as the larger stream, which was working along a line prepared by a tectonic fracture.

6. Arran compared with the Mainland of Scotland and Snowdon.

The amount of erosion in Arran attributable to glaciers depends then on the view adopted as to the geographical condition of the island at the beginning of the Glacial period. This principle is applicable to other parts of the British Isles. If the glaciers had found Scotland in the condition of a worn-down country with a mature topography many of the existing features would indicate great denudation during Glacial times by ice, frost, and rivers. If on the other hand Scotland had then an immature and rugged topography the present features could have been produced with insignificant erosion. But as Scotland was uplifted before Glacial times at least 1,000 feet, the glaciers had to work on a country with many rugged youthful features, upon which comparatively slight rock abrasion would have produced a very marked effect. The Pliocene uplift also affected England. The movement was smallest in the south; in North Wales it was as great as in Scotland, for it raised Snowdonia about 1,400 feet.[1]

The Snowdon area has many interesting analogies to Arran. Its major valleys are rectilinear, and they resemble those of Arran by their independence alike of the geological structure and natural lines of drainage. The main valleys of Snowdonia trend from north-west to south-east or from south-west to north-east. Where the

[1] In conversation with Professor O. T. Jones I was glad to find that he was also of the opinion that the Snowdon valleys had been largely made by pre-Glacial rivers eroding the uplifted plateau.

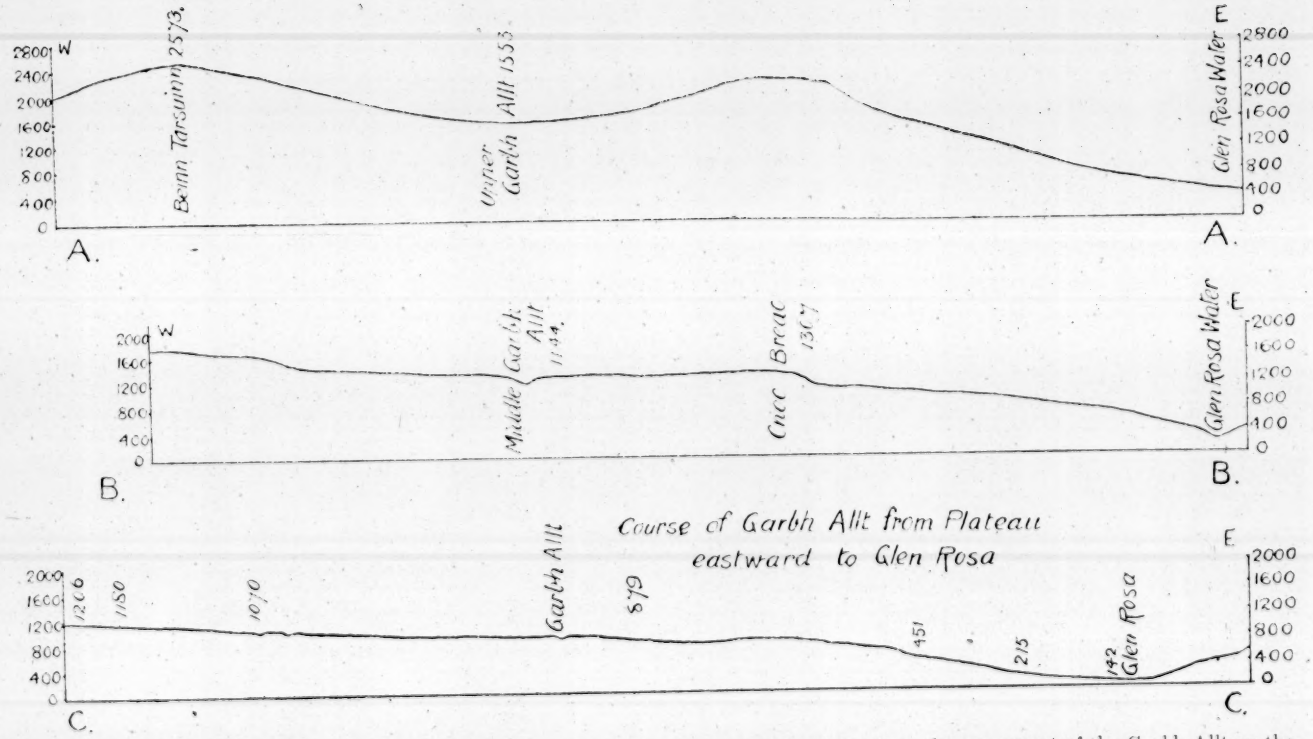

FIG. 4.—Sections across the valley of the Garbh Allt, west of Glen Rosa. A. Section across the upper part of the Garbh Allt on the plateau west of Glen Rosa. B. Section across the middle part of the Garbh Allt before its bend eastward. C. Section along the western tributary of the Garbh Allt, and its eastward course to Glen Rosa.

FIG. 5.—Sections across the valley of the Gleann Easbuig. D. Section along the divide between the Garbh Allt and the Gleann Easbuig. The main fall to Glen Rosa is further east. E. Section from N.W. to S.E. across upper Gleann Easbuig to the main valley traversed by the String Road.

valleys vary in direction they do so at sharp angles. Thus the Nant Gwynant runs north-eastward from Beddgelert to Penygwryd, where it bends east-north-east to Capel Curig ; and on the continuation of its original direction occurs the valley of Llyn Cawlyd. The Nant Gwynant–Llyn Cawlyd valley is approximately parallel to the remarkably straight course of the 500 ft. contour along the north-western and western slopes of Snowdonia.

These rectilinear valleys have cut across some of the older valleys. Thus the formation of the Llyn Cwellyn valley beheaded the Afon Drws-y-coed (the upper part of the Nantlle valley) and captured its original head streams in the Cwm-y-Clogwyn, which, both from direction and gradient, appears the natural continuation of the Afon Drws-y-coed.

The course of this network of valleys is not what would be anticipated if they had been excavated by ice. If the valleys were glacial in origin they would have been expected to radiate from Snowdon, whereas the mountain is an oblong block enclosed in a rectilinear moat. The block would be almost an exact oblong but for the sharp bend in the south-western valley, which adds a triangular area to the southern corner.

A second resemblance to Arran is that Snowdon, as was clearly pointed out by Sir Andrew Ramsay (1881, pp. 271–3), was never completely overridden by extraneous ice. It was a centre of local glaciation ; and as Ramsay remarked of its north-western glaciers (1881, p. 272), "on escaping from the high-bounding-walls of the upper parts of their valleys, they partly spread out in the shape of broad fans on the north-western slopes of the minor hills that now overlook the Straights." According to Ramsay, therefore, the valleys were pre-Glacial. The question is merely how far the glaciers enlarged and deepened these pre-existing valleys. The amount depends upon the condition of Snowdonia at the beginning of Glacial times ; and, like the mountains of Arran, Snowdon was surrounded by a high platform trenched by pre-Glacial valleys.

Snowdon, at one part of the Pliocene, was apparently a mountain about 2,000 feet high surrounded by a low, widespread plain. The district was raised by a Pliocene uplift, and the plain formed the platform that now surrounds Snowdon at the height of from 1,250 to 1,400 feet. This platform occupies most of the area between the 1,250 and 1,500 ft. contours on the map (Fig. 6). It is shown in Ramsay's section through Yr Aran (1881, p. 158, fig. 23) ; the platform is at the level of from 1,200 to 1,400 feet to the north-west of Yr Aran, and somewhat lower to the south-east of it.

The uplift of Snowdonia led to the erosion of canyons along the floors of the old valleys, the width of which indicates that they had been worn down to base-level and their walls cut backward before the Glacial period. As the climate became more severe the gullies on the upper sides of these gorges were occupied by snow, and corries were excavated about them by the combined action of frost and streams.

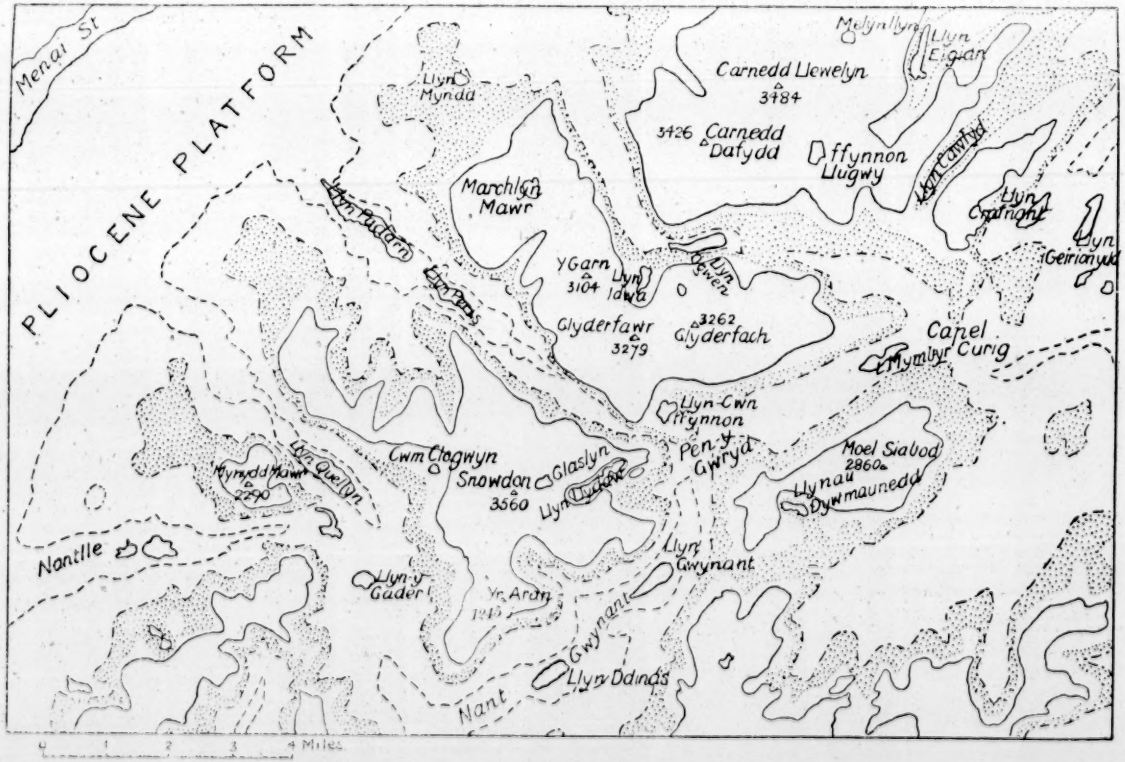

FIG. 6.—Sketch-map of the Snowdon district. The ground between the 1,000 ft. and 1,250 ft. contours is dotted to show the range of the upper platform.

When the glaciers flowed down the valleys they would have worn back the spurs, levelled the bars of rock on the floors, and thus the trough shape of the canyons, due originally to their formation along rectilinear fractures, was rendered more complete. The amount of solid rock removed by the ice according to this conception of the history of Snowdon was very small in comparison with that involved in the explanation adopted by Professor Davis. In his well-known paper both in the text and in an illuminating sketch (Davis, 1909, p. 307) he represents Snowdon at the beginning of the glaciation as a down-like upland, with gentle slopes and shallow valleys, cliffless, cragless, and without either corries or river gorges. In his paper (1909, p. 282) he describes pre-Glacial Snowdon as "a subdued

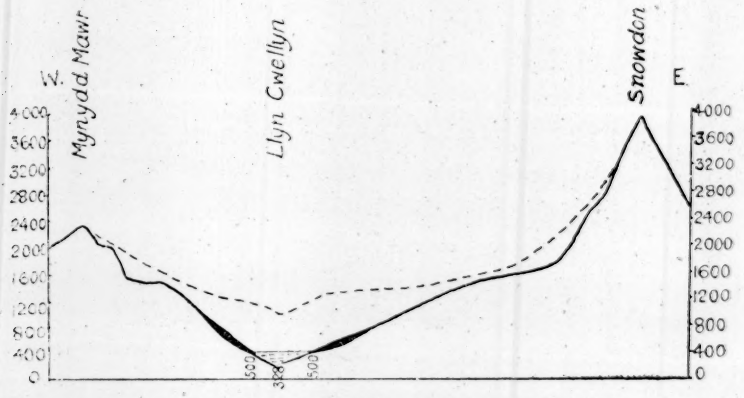

FIG. 7.—Section from Snowdon to Mynydd Mawr through Llyn Cwellyn. The broken line represents the approximate surface at the beginning of Glacial times, on the hypothesis that the down-like relief has been destroyed by glacial erosion. The areas in solid black represent the amount of solid rock removed on the alternative hypothesis that the valley had been excavated to approximately its present depth by pre-Glacial streams.

mountain form with dome-like central summit, large rounded spurs, and smooth waste-covered slopes, and with mature valleys drained by steady-flowing streams". He maintained (ibid., p. 281) that Snowdon was altered during the Glacial period and chiefly by glacial erosion from "a large featured, round-shouldered, full-bodied mountain of pre-glacial time" "into the sharp featured, hollow chested, narrow spurred mountain of to-day".

Professor Davis accepts the "late Tertiary" uplift of Snowdon, but considers that this would not have seriously changed its topography, as the only effect would have been the formation of a few minor gorges (p. 293). This conclusion is based on two arguments, first that Snowdon has no large trunk rivers, and the streams are not sufficiently different in volume to explain why some cut their valleys deeply and others were left as hanging valleys. These arguments would be conclusive if the valleys had been cut by normal consequent

streams flowing down a uniform dome. But if the major valleys be regarded as a reticular system formed along fractures which gaped open at the uplift of the country, they could have been made without trunk rivers; and the depths of the main valleys as compared with some of their tributaries is a natural consequence of the more rapid denudation along the tectonic ruptures.

Professor Davis supports his case by reference to the rounded mountains, or "Moels". He holds (1909, p. 293) that they were not overridden by northern ice or "overwhelmed by the local ice", and that their rounded forms have been retained from pre-Glacial times; and he therefore claims that the adjacent valleys were also rounded then. But if the Moels on the north-west spurs of Snowdon have retained their pre-Glacial forms, they would tell against the view that the mountain has been greatly altered by glacial erosion, since some of them were in positions especially exposed to abrasion by the ice from central Snowdon.

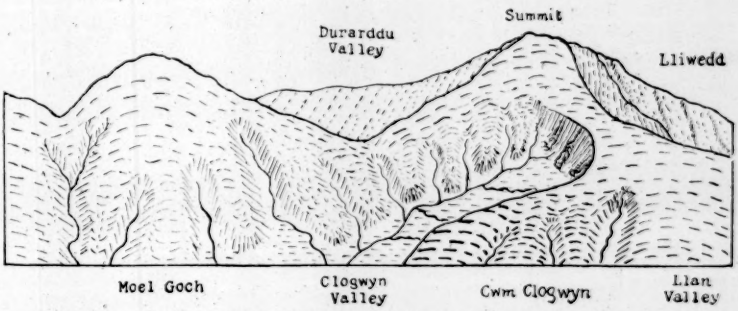

FIG. 8.—Hypothetical sketch of Snowdon from the north-west at the end of pre-Glacial times, illustrating the valleys formed in consequence of the Pliocene uplift.

As Snowdon stands in a position which rendered it subject to a heavy precipitation and is very varied in structure and composition, it appears improbable that it should have suffered so little from stream erosion during the long Pliocene uplift, as is admitted by Professor Davis' explanation. According to his view, on the section from Mynydd Mawr across Llyn Cwellyn to Snowdon, the pre-Glacial floor of the valley would have been at the present level of about 1,250 feet; Snowdon and Mynydd Mawr would have risen from the valley in gentle mature slopes along the upper boundary of the shaded area in Fig. 7. The valley below the broken line would have been excavated by glacial action.

According to the alternative view the pre-Glacial surface was along the lower line; the valley was a deep trench in the 1,200 to 1,400 ft. platform; the bed of the lake is 122 feet lower (Jehu, 1903, p. 436). The greatest removal of solid rock by the ice would have been along the edges of the Llyn Cwellyn Valley, and the amount removed would have been approximately that

marked in solid black. According to this interpretation the topography of Snowdon at the beginning of the glaciation was essentially the same as it is now. Professor Davis's sketch probably shows the nature of the mountain slopes in the early Pliocene; but at the end of that period the increased power given to the streams by the uplift had enabled them to deepen their beds until they flowed through steep-walled gorges. The aspect of the mountain if seen from the north-west would probably have been approximately as represented in Fig. 8. The earlier down-like relief had been mostly destroyed owing to the excavation of the valleys of Snowdonia, like those of Arran, by streams during the Middle and Upper Pliocene uplift.

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Note on the Determination of the Limit between the Silurian and Devonian Systems.

By L. DUDLEY STAMP, M.Sc. (Lond.), A.K.C., F.G.S.

IN a recently published paper on the "Highest Silurian Rocks of the Clun Forest District, Shropshire",[1] the present writer gave an account of an area where the series of "passage-beds", marking a gradual transition from Silurian to Old Red Sandstone conditions, is well seen. The succession there is practically identical with that established by Miss Elles and Miss Slater in the Ludlow District.[2] From November, 1918, to October, 1919, whilst engaged in a study of Belgian Tertiary rocks, I have had an opportunity of visiting some of the more important sections of the Gedinnian in the Ardennes and also of examining the palæontological collections at Brussels, Lille, and elsewhere. This work has thrown very considerable

[1] Quart. Journ. Geol. Soc., vol. lxxiv, 1918, p. 221, 1919.
[2] Ibid., vol. lxii, 1906, p. 195.

light on the English succession, and it seems desirable to give here a resumé of the conclusions reached.

I. NOTES ON THE SUCCESSION IN BELGIUM, NORTH FRANCE, AND ENGLAND.

A. The Ardennes.

The generalized section of the base of the Devonian in the Ardennes is as follows :—

Gedinnien supérieur . .	Schistes de Saint-Hubert. Schistes d'Oignies.
Gedinnien inférieur . .	Schistes de Mondrepuits. Arkose de Haybes and Arkose de Weismes. Poudingue de Fépin.

Well-marked unconformity.

Cambro-Silurian rocks, of which the most recent are of Wenlock and Lower Ludlow age.

The fauna of the Lower Gedinnian is not a large one, and has fortunately been reviewed in recent years by Professor Leriche in "La faune du Gedinnien inférieur de l'Ardenne".[1] The fauna there described comprises thirty-three species, excluding the Ostracoderms, described elsewhere by the same author.[2]

(*a*) *Gedoumont, near Malmedy, Belgian Prussia.*

Here the Lower Gedinnian, resting on Cambrian, is represented by a white sandstone (Grès de Gedoumont), which is perhaps the equivalent of part of the Schistes de Mondrepuits as well as the Arkose de Haybes. By far the most abundant fossils are *Chonetes striatella*, and a Rhynchonellid, identified by Leriche as *Rh. nucula*. It is a small form, apparently identical with the small form I have called *Rh. nucula* var., and noted as characteristic of the Upper *Chonetes* Flags in Shropshire.[3] It occurs also in the *Platyschisma* shales. The association of these two fossils is at once striking and suggestive to one who has studied the Upper *Chonetes* Flags of Shropshire. Occurring commonly also in the Grès de Gedoumont are *Orthis* cf. *lunata*, *Pterinæa retroflexa*, and corals (*Petraia bina* and *Cystiphyllum profundum*). The Devonian affinities of the fauna are seen especially in the occurrence of *Cryphæus* and numerous examples of *Spirifer Dumonti* (de Koninck). The latter may prove to be a derivative of *Sp. elevatus*.

(*b*) *Gileppe, near Verviers.*

Here the Gedinnian rests on Salmian rocks with *Dictyonema sociale*. The locality is to the north of the last (north of the "massif" of Stavelot), and the deposits are of the type generally referred to as Old Red Sandstone. They consist of rubbly green or red shales, with abundant cornstones, very closely resembling some

[1] Mém. Musée royal d'Hist. nat. de Belgique, vol. vi, 1912.
[2] Mém. Soc. géol. du Nord, vol. v, 1906, pp. 26–39.
[3] Loc. cit., p. 231.

of the Temeside shales of Shropshire. The discovery of marine fossils in the latter has shown the folly of identifying this type of lithology exclusively with lacustrine conditions.

The Gedinnian has a similar facies to the south of Pepinster.

(*c*) *The Meuse Valley, south of Givet.*

Here some splendid sections show the Poudingue de Fépin—a thick, though local, conglomeratic base of the Arkose de Haybes—resting on the upturned and eroded beds of the Cambrian. The Arkose is succeeded by the Schistes de Mondrepuits (which are not here very fossiliferous) and then by the Upper Gedinnian.

(*d*) *Mondrepuits and Macquenoise.*

Here occur the most fossiliferous exposures of the Lower Gedinnian (Schistes de Mondrepuits). The most abundant fossil is *Rhynchonella nucula*, again the small form of the top of our *Chonetes* Beds. Other characteristic fossils include *Pterinæa retroflexa*, *Bellerophon trilobatus*, *Spirifer sulcatus*, and *Orthis personata* (Zeiler), the latter (well-known from the Coblentzian) indicating clearly the affinities of the fauna with the succeeding Devonian.

B. The North of France (Pas-de-Calais).

During the German occupation of Lille, Professor C. Barrois, Dr. P. Pruvost, and M. G. Dubois employed the leisure of their forced confinement in the city in studying a large series of specimens of Silurian and Devonian rocks from shafts and borings round Liévin, Lens, Béthune, etc. A complete series of transition rocks from the Silurian (Aymestry horizon) to the Devonian occurs in this region, thrust over the Pas-de-Calais Coalfield. Results of very great interest and importance have resulted from this study, of which, apart from previous descriptions of a small part of the fauna,[1] only a short resumé has yet been published.[2]

I am deeply indebted to Professor Barrois and Dr. Pruvost, who have allowed me to examine the specimens at the University of Lille.

The succession established is as follows :—

		Thickness in metres.
Gedinnien supérieur	Schistes et grès rouges et verts de Vimy	about 200
	Schistes et grès rouges et verts de Pernes	about 200
Gedinnien inférieur	Psammites de Liévin	about 80
	Schistes de Méricourt	23
	Arkose de Bois-Bernard	0–6
Gothlandien supérieur	Grauwacke de Drocourt	22
	Calcaire d'Angres	62
	Calcaire de Liévin	12

[1] Gosselet, Barrois, Leriche, & Crépin, "Description de la Faune silurodévonienne de Liévin" : Mém. Soc. géol. du Nord, vol. vi (ii), 1912. Leriche, Mém. Soc. géol. du Nord, vol. v, 1906.

[2] C.R. des Séances de l'Acad. des Sci. (Inst. de France), vol. 167, 1918, p. 705.

The Calcaire de Liévin has yielded six species, with *Dayia navicula* in great abundance.

The Calcaire d'Angres is a blue limestone, crinoidal at the base, with thirty-two species, including *Rhynchonella nucula* (large form identical with the characteristic form found in our *Rhynchonella* Beds), *Acaste Downingiæ*, *Calymene Blumenbachii*, and *Leptæna rhomboidalis*.

The Grauwacke de Drocourt has yielded sixty-three species, including *Spirifera elevata*, *Orthis lunata*, *O. canaliculata*, *Homalonotus* spp., *Pterinæa retroflexa*, and numerous Orthoceratids, including the "nodules à *Orthoceras*", so well seen in the *Rhynchonella* and *Chonetes* Beds of Shropshire.[1]

The Arkose de Bois-Bernard is a local bed of coarse sandstone at the base of the Schistes de Méricourt.

The Schistes à *Tentaculites* de Méricourt yield a very rich fauna of fifty-eight species, including *Retzia Bouchardi*, *Tentaculites irregularis*, *Pterinæa retroflexa*, and other lamellibranchs, *Cryphæus* spp., abundant *Primitia Jonesi*, *Orthis personata*. There can be no doubt of the identity of this bed with the Schistes de Mondrepuits.

The Psammites de Liévin have alternating beds with *Pteraspis Gosseleti* (Leriche), *Cyathaspis Barroisi* (Leriche), and typical marine beds with *Modiolopsis complanata* and *Orbiculoidea*.

The Schistes et grès de Pernes and the Schistes et grès de Vimy are only separable by their faunas, the former being characterized by *Pteraspis Crouchii*, *Pt. rostrata*, and *Cephalaspis Lyelli*; the latter by a rich and entirely different series of fish remains not yet described.

C. Shropshire.

It is not necessary to repeat here the well-known established sequence in Shropshire.[2]

The beds, which I have termed in the western area the *Platyschisma* shales, represent a deeper-water facies of the lower part of the Downton Castle Sandstone. The fossils mentioned on p. 233 of my paper as being survivals from the *Chonetes* Beds are perhaps more correctly regarded as the continuation of the normal fauna, whereas the fauna associated with *Platyschisma helicites* is a specialized shallow-water one. This point needs further investigation.

II. NOTE ON THE CORRELATION TABLE (p. 169).

This is practically identical with that already advocated by Barrois, Pruvost, and Dubois (op. cit.), who approached the subject from an entirely different standpoint—that of the study of the faunas in the North of France. My conclusion as to the relation of the

[1] Stamp, loc. cit., pp. 228–9.

[2] Elles & Slater, Quart. Journ. Geol. Soc., vol. lxii, 1906, p. 195; Stamp, ibid., vol. lxxiv, 1918, p. 221, 1919.

Gedinnian of the Ardennes with the English Downtonian[1] was formed before seeing their paper, or knowing of the succession in North France, and it has been amply confirmed by the wonderful series there exhibited.

III. WHERE SHOULD THE BOUNDARY BETWEEN THE SILURIAN AND DEVONIAN SYSTEMS BE PLACED?

(1) Palæontological Evidence.

The Silurian and Devonian systems were originally described from their development in England, where there is nowhere a superposition of typical marine Devonian on typical marine Silurian. The later detailed classification of the Upper Silurian and "Downtonian" has been formed on the supposition that the upper limit of the Silurian coincided with a change of facies from marine to lacustrine—a truly unsatisfactory basis for international correlation.[2]

The palæontological affinities of the fauna of the Gedinnian are briefly noted above. Those geologists who have advocated the placing of the Gedinnian in the Silurian have undoubtedly been correct in recognizing the close connexion of Gedinnian and Downtonian.[3] The difficulties of correlation largely disappear when Downtonian is considered as Devonian, since the supposed Silurian character of the Gedinnian lamellibranch fauna cannot be considered as of great importance. Palæontologists are generally agreed as to the unsatisfactory nature of lamellibranchs as zonal forms, and in any case our Silurian species are very imperfectly known.

In North France the percentages of Silurian and Devonian species in each bed have been worked out, and on this basis the summit of the Silurian should be taken at the top of the Grauwacke de Drocourt.

In Britain it is necessary to rely principally on fish remains, which, with one or two exceptions, are first found in the Ludlow Bone-bed. The Downtonian and Lower Old Red Sandstone are united by several genera and even species of Ostracoderms.

(2) Stratigraphical Evidence.

The Silurian sea of Upper Ludlow times was of comparatively limited extent. In Lower Gedinnian times on the continent of Europe the sea spread over a vast tract of country in the Ardennes[4]—

[1] Throughout this note the term "Downtonian" is used in its restricted sense, applying only to beds above the horizon of the Ludlow Bone-bed.

[2] See Evans, Geol. Mag., Vol. LVI, 1919, p. 549.

[3] Leriche, "Poissons fossiles du Nord de la France": Mém. Soc. géol. du Nord, vol. v, 1906, pp. 13–21.

[4] Compare South Devon and Cornwall, Green and Sherborn, Geol. Mag., 1913, p. 70.

TABLE OF CORRELATION.

	Ardennes.	N.E. France (Pas-de-Calais)	Shropshire.	South Wales [2] (Ammanford District, etc.).
Upper Gedinnian	Schistes de Saint-Hubert Schistes d'Oignies	Schistes et grès de Vimy Schistes et grès de Pernes	? [1]	Lower Old Red Sandstone
Lower Gedinnian	Schistes de Mondrepuits Arkose de Haybes. Poudingue de Fépin.	Psammite de Liévin. Schistes de Méricourt. Arkose de Bois-Bernard.	Temeside Shales. Downton Castle Sandstone, including *Platyschisma* Shales. Ludlow Bone-bed at the base.	Red Marls (part) with Green Basal beds. Tile stones. Trichrûg beds. *Grammysia* beds.
Upper Ludlow Group	Absent.	Grauwacke de Drocourt. Calcaire d'Angres.	*Chonetes* beds. *Rhynchonella* beds.	Upper Ludlow.
Aymestry Group		Calcaire de Liévin.	*Dayia* Shales. Aymestry Limestone.	Aymestry Group.

[1] The lower part of the beds at present called Old Red Sandstone in Shropshire are probably equivalent to the "Red Downtonian" of Staffordshire (see King and Lewis, Proc. Birmingham Nat. Hist. and Phil. Soc., vol. xiv, 1917, p. 90). The latter beds yield *Scaphaspis truncatus*, *Eukeraspis*, etc., and must therefore be linked with the Temeside Shales as Downtonian and equivalent to the Schistes de Mondrepuits. True Lower Old Red Sandstone (*Pteraspis*, *Cephalaspis lyelli*) when defined in Shropshire would be placed here as equivalent to the Upper Gedinnian.

[2] The correlation of the beds in South Wales is a matter of considerable difficulty. Some localities exhibit a sequence comparable with that of Shropshire and show a complete and conformable series from Upper Ludlow to Lower Old Red Sandstone. (For example, east of the Ammanford area, see *Geol. Country around Ammanford*, Mem. Geol. Surv., 1907, p. 53; and on the Pembrokeshire coast, see *Geol. Country around Milford*, Mem. Geol. Surv., 1916, pp. 77, 97.) In South Wales there seems to be evidence of successive overstep, which is most pronounced at the base of the Red Marls (including their Green Basal Beds). The Red Marls are regarded as Lower Old Red Sandstone by the Survey on the evidence afforded by the discovery of *Eukeraspis* in the basal beds at one locality (see *Geol. Country around Newport*, Mem. Geol. Surv., 1909, p. 15), but this genus is characteristic of Downtonian rocks (including Downton Castle Sandstone) in Shropshire and North Staffordshire. It is true *Pteraspis* occurs in the upper part of the Red Marls, but it is possible, or even probable, that the lower part may be homotaxial with the Temeside Shales, with which there is a great lithological resemblance.

the greater part of the present Bassin de Dinant—and gave rise to well-marked basal conglomerates and sandstones (Poudingue de Fépin and Arkose de Haybes). The movement was isostatic in its nature, and was coincident with a shallowing of the pre-existing Upper Ludlow sea in North-East France. A very similar isostatic movement seems to be indicated in South Wales as noted on the correlation table. Thus in North-East France, Shropshire, and certain districts of South Wales, although there is a gradual transition from the Upper Ludlow to the shallower-water deposits of Downtonian age, the most widely spread disturbance, heralding the advent of the Devonian period, occurs in Lower Gedinnian and early Downtonian times. The commencement of this movement may possibly be indicated by the Ludlow Bone-bed.

In Scotland the Downtonian rocks[1] are sometimes seen to rest conformably on Upper Ludlow, with or without a conglomerate at the base; but an important transgression of the sea is indicated, for example, in Kincardineshire,[2] where Downtonian rocks, conformably overlain by Lower Old Red Sandstone, rest on ? Upper Cambrian. In the Southern Uplands there is sometimes a marked discordance (Pentland Hills and Ayrshire), and sometimes apparent conformity (Lanarkshire), between the Lower Old Red Sandstone and the Downtonian. The folding in the district is so intimately connected with the volcanic activity of Old Red Sandstone times, that the area must be considered in relation to others rather than by itself.

From the standpoint of physical geology, surely the only logical view is to regard the Downtonian as the commencement of the Devonian Period. To regard it as Silurian is to admit the enormous extension of the Silurian sea at the very end of the period, almost everywhere to be succeeded imperceptibly by Devonian or Old Red Sandstone, the rocks of the latter having, except in special cases, no natural stratigraphical base.

To this it may be objected that the Upper Gedinnian of North-East France and Belgium, as well as parts of the succeeding Coblentzian, are of "Old Red Sandstone" type, and are therefore to be regarded as marking the close of a period rather than as an integral part of the Devonian Period. Truly the rocks of this age in the Ardennes are not rich in fossils, and consist frequently of sandstones, indicating shallow-water conditions unfavourable to life. But lithology is by no means a sure indication of lacustrine or true Old Red Sandstone conditions. The discovery of marine fossils in the Downtonian of England—including the Temeside Shales of Clun Forest—in rocks which were regarded as typical of Old Red Sandstone, is paralleled in Belgium in the work of Dr. E. Asselbergs. This geologist, well

[1] *Silurian Rocks, Scotland* (Mem. Geol. Surv.), 1899, pp. 68–9, p. 568 et seq.

[2] Campbell, "The Geology of South-Eastern Kincardineshire": Trans. Roy. Soc. Edin., vol. xlviii, 1913, p. 923.

known for his work on the Devonian, has traced fossiliferous marine bands in the Lower Coblentzian of the South of Belgium (Bassin d'Eifel),[1] and is of the opinion that the Old Red Sandstone (lacustrine) facies does not exist at all in the Ardennes. The existence of shallow-water and sparsely fossiliferous rocks in the Upper Gedinnian and Lower Coblentzian is only the natural consequence of the huge transgression and attendant shallowing of the sea in Lower Gedinnian times, and cannot be regarded as representing a change separating two periods—the Silurian and Devonian.

(3) Considerations of Priority.

Murchison originally drew the line of division between his Silurian and his Old Red Sandstone systems in Shropshire just above the Ludlow Bone-bed. It was only the occurrence of many of the Upper Ludlow fossils in the "Tilestones" (= Downton Castle Sandstone) that induced him to include the latter in the Silurian.[2] For reasons of priority it would be preferable to include the Bone-bed still in the Silurian, but there is evidence to show that bone-beds tend to occur at the base rather than at the summit of systems. The writer considers the Ludlow Bone-bed as an "organic" basal conglomerate marking the base of the Devonian system.

IV. CONCLUSION.

The absence of a clearly defined limit between the Silurian and Devonian in England has long been a great hindrance to workers both here and abroad. The result has been apparent in recent years in the so-called "Gedinnian problem", i.e. as to whether the Gedinnian is to be considered as Silurian or Devonian.[3] It is at least desirable that a statement of our present knowledge should be clearly outlined. After the publication of the detailed account of the succession in North-East France, and also of further work on the Downtonian fish faunas of England,[4] it is hoped that the whole subject will be treated more fully by Dr. Pierre Pruvost and myself.

[1] Mém. de l'Inst. géol. de l'Univ. de Louvain, vol. i, 1913.

[2] *Siluria*, 4th ed., 1867, pp. 134–5.

[3] See De Dorlodot, Bull. Soc. belge Géol., vol. xxvi, 1912, Proc. verb. pp. 17–39, 62–5; Ann. Soc. géol. Belgique, vol. xxxix, 1912, pp. M 291–M 371. Mailleux, "Le texte explicatif du lévé géol. de la plan. de Couvin," 1912 (Serv. géol. Belgique): Bull. Soc. belge Géol., vol. xxvi, 1912, Proc. verb. p. 139. Fourmarier, Ann. Soc. géol. Belgique, vol. xxxix, 1912, p. 233. Leriche, Bull. Soc. belge Géol., vol. xxv, 1911, Proc. verb. p. 327.

[4] Indicated by King & Lewis, Proc. Birmingham Nat. Hist. and Phil. Soc., vol. xiv, 1917, p. 90.

Carboniferous Fossils from Siam.

By F. R. Cowper Reed, M.A., Sc.D., F.G.S.

(*Concluded from p. 120.*)

Athyris subtilita (Hall). (Pl. II, Fig. 10.)

One internal cast of the pedicle-valve of a species of *Athyris* seems indistinguishable from *A. subtilita* Hall[1] which occurs in the Carboniferous of Belgium,[2] and has recently been recorded from Eastern Yunnan.[3] The general shape and narrow median sulcus, the concentric sublamellose growth-ridges, and small, parallel dental plates, are well seen in our specimen.

Spirifer (*Reticularia*) cf. *lineatus* Martin.

The peculiar and characteristic ornamentation of *Sp. lineatus* is found on a fragment of a crushed valve in the collection. This well-known species occurs in the Culm of Hagen, according to Nebe,[4] as well as elsewhere.

Camarophoria sp. (Pl. II, Figs. 11, 12.)

There is the flattened impression and the cast of the left half of the valve of a small brachiopod, possessing characters which indicate its reference to the genus *Camarophoria*. The beak is not preserved, and it is doubtful if it is the brachial or pedicle valve with which we have to deal. The cardinal angles are rounded; there are 4–6 faint, low, rounded ribs on each side of a median weak sinus, which also bears two or three ribs, but the lateral portions of the shell are devoid of ribs, and simply show a few strong concentric growth-ridges. These external characters seem to suggest a comparison with *C. Dunkeri* (Roemer) as interpreted by Holzapfel.[5] Another, but uncrushed specimen (Pl. II, Fig. 12) consists of the internal cast of a pedicle-valve, 12·5 mm. long and 15 mm. wide, which shows the triangular spondylium.

Productus concentricus Sarres-Kayser. (Pl. II, Fig. 13.)

There is one brachial valve of a species of *Productus* which seems to correspond precisely with the form described and figured by Kayser[6] as *Pr. concentricus* Sarres, from the Rhenish Culm. Our specimen, which measures 9 mm. in width, shows the ornament and shape distinctly, and is fairly well preserved. Another less

[1] Davidson, *Mon. Brit. Foss. Brach.*, vol. ii, pp. 18, 86, 217, pl. i, figs. 21–2; pl. xviii, figs. 8–10.

[2] De Koninck, *Faune Calc. Carb. Belg.*, vol. iv, pt. vi, p. 73, pl. xviii, figs. 1–4, 12–28.

[3] Mansuy, op. cit., vol. i, fasc. ii, pt. ii, 1912, p. 92, pl. xvii, fig. 2; p. 98, pl. xviii, fig. 6.

[4] Nebe, op. cit., p. 447, t. xiv, fig. 14.

[5] Holzapfel, op. cit., p. 65, t. vii, fig. 8.

[6] Kayser, *Jahrb. k. preuss. geol. Landesanst.*, 1882 (for 1881), p. 83, t. iii, figs. 3, 4.

perfect example agrees with Kayser's fig. 4 of the same species. Bather [1] has described and figured this species from the Lower Culm Measures of Devonshire, and it seems to be characteristic of the Lower Carboniferous.

Productus lævipunctatus Sarres. (Pl. II, Fig. 14.)

One small internal cast of a nearly complete but slightly distorted pedicle-valve, with the brachial-valve displaced but attached, appears to be indistinguishable from the shell figured by Kayser [2] as *Productus lævipunctatus* Sarres. Our specimen is not crushed, and the shape of the pedicle-valve and large incurved beak are well seen. The species occurs typically in the Culm of the Continent.

Productus cf. *plicatus* Sarres.

The impression of part of a brachial-valve of a species of *Productus* showing the ornamentation may be compared with *Pr. plicatus* Sarres,[3] which occurs in the Culm of the Continent, and probably also in the Lower Culm of Devonshire.[4]

Chonetes cf. *rectispina* Von Koenen. (Pl. II, Fig. 15.)

In one of the specimens of a small species of *Chonetes*, the cardinal spines are preserved, and there are four on each side of the beak, successively increasing in length outwards, and all are directed nearly at right angles to the hinge-line. The shell itself is semi-elliptical to semicircular, and the cardinal angles are rectangular. The surface is not well preserved, but seems to have been covered with close, fine, radiating lines. In its characters, so far as known, it resembles *Ch. perlata* (McCoy),[5] but more especially *Ch. rectispina* Von Koenen,[6] from the Culm of Germany and Barnstaple.[7] *Ch. pseudovariolata* Nikitin,[8] which is figured by Loczy [9] and Schellwien [10] from the Carboniferous of China, possesses the same general shape and ornament, but the cardinal spines are rather obliquely directed outwards. Our best specimen from Siam measures 6 mm. in length and 9·5 mm. in width.

[1] Bather, Quart. Journ. Geol. Soc., vol. li, 1895, p. 650, pl. xxviii, figs. 9, 9*a*, 9*b*.

[2] Kayser, *Jahrb. preuss. geol. Landesanst.*, 1882 (for 1881), p. 80, t. iii, fig. 5.

[3] Kayser, ibid., p. 81, t. iii, figs. 1, 2; Leyh, *Zeitschr. deut. geol. Gesell.*, xlix, 1897, p. 540.

[4] Bather, Quart. Journ. Geol. Soc., vol. li, 1895, p. 649, pl. xxviii, figs. 10, 10*a*, 10*b*.

[5] McCoy, *Syn. Carb. Foss. Irel.*, 1844, p. 120, pl. xx, fig. 9.

[6] Von Koenen, *Neues Jahrb. f. Min. Geol.*, 1879, p. 327, t. vii, figs. 4*a*, 4*b*. Kayser, *Jahrb. k. preuss. geol. Landesanst.*, 1882 (for 1881), p. 78, t. iii, figs. 13, 14.

[7] Bather, Quart. Journ. Geol. Soc., vol. li, 1895, p. 650, pl. xxviii, figs. 12, 12*a*, 12*b*.

[8] Nikitin, Dép. Carb. Moscou, Mém. Com. Géol. Russ., vol. v, No. 3, 1890, p. 27, t. ii, figs. 1–4.

[9] Loczy, op. cit., p. 73, pl. iii, figs. 8–13.

[10] Schellwien, in Futterer's *Durch Asien*, Bd. iii, Lief. i, 1903, p. 142, t. i, figs. 5–8.

Chonetes aff. *buchiana* De Koninck. (Pl. II, Fig. 16.)

Another species of *Chonetes* is represented by the internal cast of a pedicle-valve and the interior view of the same valve. The ribs, which are comparatively few (about twenty to twenty-five in all), and coarse, are equally and widely spaced, and show faintly through the substance of the shell, and the two pairs of muscle-scars are distinct. The valve is gently convex, slightly flattened near the cardinal angles, which are rectangular, and the beak is small and inconspicuous. There are several small, short, cardinal spines along the hinge-line. The shell measures about 8 mm. in width and 5 mm. in length. The species is probably allied to, if not identical with, *Ch. buchiana* De Kon.[1]

Chonetes sp.

There is the cast and impression of the pedicle-valve of another small *Chonetes*, which is distinct from that above described. It is transversely subtriangular and fusiform in shape, with acutely pointed and somewhat produced lateral angles, and is widest along the hinge-line. The median portion of the valve is strongly convex, and rises rather suddenly from the depressed lateral portions. The cardinal angles are pointed at about 45 to 60 degrees; the beak is obtuse and small, and scarcely projects over the hinge-line. The surface of the valve is covered with rather coarse, though small, rounded riblets, about thirty-five to forty in number. The internal cast shows rather large and widely separated pustules arranged in radial lines, and there are traces of narrow elongated muscle-scars. There are indications of the bases of a few small cardinal spines along the hinge-line. Dimensions: width, 8·5 mm.; length, 4·5 mm. The shape of our shell recalls *Leptæna convoluta* Phill.[2] from the Devonian of Croyde Bay, which McCoy[3] records from the Carboniferous of Ireland. Loczy's *Chonetes Flemingi* var. *gobica*,[4] from the Carboniferous of China, may also be compared.

Proetus cf. *coddonensis* Woodward. (Pl. II, Fig. 17.)

Description.—Pygidium transversely semicircular. Axis strongly convex, broad, about one-third the width of the pygidium and three-fourths its length, composed of seven complete rings with narrow, lateral portions indistinctly marked off by weak longitudinal furrows; tip bluntly pointed. Pleural lobes somewhat flattened, with four distinct pleuræ on each side (and traces of a fifth), and a half-pleura on each front edge; pleuræ radiating, straight, extending nearly to the margin of pygidium, successively decreasing in strength and length posteriorly, with raised subangular surface bearing a fine median furrow; interpleural furrows well marked. Fine weak marginal furrow, indistinctly separating off a rounded border.

[1] De Koninck, *Anim. Foss. Carb. Belg.*, 1842–51, p. 208, pl. xii, figs. 1*a*–1*c*.
[2] Phillips, *Palæont. Foss. Cornw. Dev.*, p. 57, pl. xxiv, fig. 96.
[3] McCoy, *Syn. Carb. Foss. Irel.*, p. 119.
[4] Loczy, op. cit., p. 77, t. iii, fig. 14, text-fig. 15.

Surface of pygidium very finely granulated. Dimensions: length, 5 mm.; width, 8·5 mm.

Remarks.—Two pygidia occur on opposite sides of the same piece of rock, one with the shell preserved and the other in the condition of a hollow impression. These were identified by Professor Hughes as *Proetus*. The very short pygidium and small number of segments of which it is composed seem to necessitate the reference of these specimens to this genus rather than to *Phillipsia* or *Griffithides*, and we may compare it with the Lower Culm species, *Proetus* sp. *a*[1] and *Pr. coddonensis* Woodw.[2] from North Devon. *Pr. postcarbonarius* Gemmellaro,[3] from the Sosio Limestone of Sicily, seems also to be allied to our form. It is undoubtedly distinct from the species *Proetus ellipticus* Mansuy,[4] from the Dinantian of Eastern Yunnan, which seems to be the only species of the genus previously recorded from the Carboniferous of South-Eastern Asia. The occurrence of this typically Devonian and Silurian genus in these Siamese beds is a token of their low stratigraphical position in the Carboniferous. Apart from the Devonshire species, the only Carboniferous representatives on the Continent are *Pr.* (*Dechenella*) *angustigenatus* Leyh, and *Pr.* (*D*) *hopensis* Leyh, from the Posidonienschiefer of the neighbourhood of Hof.[5]

Phillipsia aff. *silesiaca* Scupin. (Pl. II, Fig. 18.)

One small imperfect middle shield occurs in the collection, measuring between 3 and 4 mm. in length, but there is sufficient preserved to decide its reference to the genus *Phillipsia*, though the species cannot be determined. The glabella is semi-oval, somewhat elongated, widening slightly posteriorly, with nearly straight sides, and it consists principally of a large somewhat swollen median lobe overhanging the front end, with a pair of very short lateral, nearly horizontal furrows indenting its sides and marking off incompletely a pair of very small lateral lobes, which are bounded posteriorly by the deeper and stronger short oblique basal furrows not reaching the meso-occipital furrow. The basal lobes are small, swollen, subtubercular, and subtriangular, and they are widely separated from each other by about three times their width. The eye-lobes are long, narrow, and rounded, and are closely pressed against the sides of the glabella, reaching from a point about half its length to behind the basal lateral furrows. The fixed cheek behind them seems to be very small, but this part is not well preserved. Several species of this genus have been described from the Lower Culm near Hof[6] and from the Lower Carboniferous of Silesia, and ours especially

[1] Woodward, Quart. Journ. Geol. Soc., vol. li, 1895, p. 648, pl. xxviii, figs. 7, 7*a*.
[2] Woodward, Geol. Mag., Dec. IV, Vol. IX, 1902, p. 483, Pl. XX, Figs. 5–11.
[3] Frech, *Leth. Geogn.* I, *Palæoz.*, Bd. ii, Lief. iv, 1902, p. 506, t. 596, fig. 5.
[4] Mansuy, op. cit., vol. i, fasc. ii, pt. ii, 1912, p. 85, pl. xvi, fig. 2.
[5] Leyh, *Zeitschr. deut. geol. Gesell.*, xlix, 1897, pp. 522, 524, t. xvii, figs. 1, 2.
[6] Ibid., pp. 526–7, t. xvii, figs. 3, 4.

resembles *Ph. silesiaca* Scupin.[1] One of Nebe's figures[2] of a glabella attributed to his species *Phillipsia westphalica*, which does not show any lateral furrows, also seems somewhat to resemble our specimen.

Cythere (?) sp.

A minute oval ostracod, measuring less than 2 mm. in length, and with rather pointed extremities, occurs in the collection, but is not sufficiently well preserved for a description, but it may be referred to the genus *Cythere*.

Cladochonus cf. *Michelini* (Edwards & Haime). (Pl. II, Fig. 19.)

Three narrow, elongated, tubular corallites, expanding slightly at their funnel-shaped mouths and connected in a longitudinal linear manner, with a slight alternate direction to the right and left, may be compared without hesitation to the *Cladochonus Michelini* Edw. & H., as figured by Kayser[3] from the Rhenish Culm. This species also occurs in the Coddon Hill Beds of Barnstaple.[4] It seems closely similar in mode of growth to *Cl. Schlüteri* Holzapfel,[5] from the Rhenish Devonian. In our specimen from Siam the total length of the corallites is about 30 mm., the successive corallites measuring respectively 11 mm., 13 mm., and + 9 mm.

LIST OF FOSSILS FROM KUAN LIN SOH.

Pronorites aff. *cyclolobus* (Phill.).
Prolecanites (?) sp.
Nomismoceras (?) sp.
Glyphioceras (?) sp.
Pleurotomaria (*Mourlonia*) aff. *conica* Phill.
Euomphalus cf. *subcircularis* Mansuy.
Helminthochiton cf. *priscus* (Münster).
Parallelodon aff. *corrugatus* (De Kon.).
Edmondia sp.
Allorisma (?) sp.
Protoschizodus (?) sp.
Posidonomya Becheri Bronn, var. *siamensis* nov.
,, cf. *radiata* Wh. Hind.
Pseudamusium cf. *pratenue* (Von Koenen).
Aviculopecten cf. *densistria* (Sandb.).
Actinopteria sp.
Athyris subtilita Hall.
Spirifer cf. *lineatus* Mart.
Camarophoria sp.
Productus concentricus Sarres-Kays.
,, *lævipunctatus* Sarres.
,, cf. *plicatus* Sarres.

[1] Scupin, ibid., lii, 1900, p. 8, t. i, figs. 1–3.
[2] Nebe, op. cit., p. 474, t. xii, fig. 4.
[3] Kayser, *Jahrb. k. preuss. geol. Landesanst.*, 1882 (for 1881), p. 85, t. iii, fig. 19.
[4] Hinde & Fox, Quart. Journ. Geol. Soc., vol. li, 1895, p. 644, pl. xxviii, figs. 19, 19*a*.
[5] Holzapfel, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft xvi, 1895, p. 305, t. xii, figs. 1, 2, 4, 5, 7

Chonetes cf. *rectispina* Von Koenen.
,, aff. *buchiana* De Kon.
,, sp.
Proetus cf. *coddonensis* Woodw.
Phillipsia aff. *silesiaca* Scupin.
Cythere (?) sp.
Cladochonus cf. *Michelini* (Edw. & Haime).
Crinoid stems.

Conclusions.

In 1913 Mr. J. B. Scrivenor [1] referred to the above described collection of Siamese fossils as probably belonging to his "Raub Series", which he regarded as of Carboniferous and Permo-Carboniferous age, and a specimen of the fine-grained fossiliferous shale, which I sent for his inspection in 1916, was pronounced as resembling "weathered decalcified shale" of this series. We are unfortunately without any knowledge of the field-relations of the Patalung rocks, but the occurrence of beds of Carboniferous age in other parts of South-Eastern Asia, the East Indies, and China is well established. Since Scrivenor (op. cit.) gave a list of references to most of the literature, the important work of MM. Mansuy and Deprat [2] has appeared on Annam, Tonkin, and Yunnan, while Fliegel's [3] memoir should also not be forgotten in addition to those by Schellwien and Loczy, which have been quoted in the foregoing papers. Högbom's [4] recent summary of the geology of Siam does not deal with the Patalung region, and no fauna of a similar type is mentioned as occurring elsewhere in the country. The whole facies of the fauna is undoubtedly that of the Culm, and several of the species seem to be identical or very closely comparable with species occurring in beds of this age on the Continent and in the south-west of England. A remarkable lithological similarity is noticeable between these Siamese beds and those of Coddon Hill, near Barnstaple,[5] and the state of preservation of the fossils is practically identical, though no radiolaria have been so far discovered in the former. The species of *Posidonomya*, moreover, is scarcely separable from the typical Culm form, *P. Becheri*.

It is not possible to detect any faunistic resemblance to the Permo-Carboniferous or Productus Limestones of India and other parts of Asia, and the whole palæontological evidence appears to point to a reference of the beds to an older set of deposits, and to prove the occurrence of Culm conditions and a Culm fauna in this part of Siam.

[1] Scrivenor, Quart. Journ. Geol. Soc., vol lxix, 1913, p. 352.
[2] Mansuy & Deprat, Mém. Serv. Géol. Indo-chine, vol. i, fasc. ii and iv, 1912; vol. ii, fasc. iii and iv, 1913.
[3] Fliegel, *Palæontographica*, Bd. xlviii, 1901, pp. 91–136, t. vi–viii.
[4] B. Högbom, Bull. Geol. Inst. Univ. Upsala, vol. xii, 1913–14, pp. 63–128, map, pl. i.
[5] G. J. Hinde & H. Fox, Quart. Journ. Geol. Soc., vol. li, 1895, pp. 609–68, pls. xxiii–xxviii.

PLATE II.

FIG.

1. *Pronorites* aff. *cyclolobus* (Phill.). × 1½.
2. *Pleurotomaria* (*Mourlonia*) aff. *conica* Phill. × 1½.
3. *Euomphalus* cf. *subcircularis* Mansuy. × 2.
4. *Helminthochiton* cf. *priscus* (Münst.). × 2.
5. *Parallelodon* aff. *corrugatus* De Kon. × 1½.
6. *Edmondia* sp. × 2.
7. *Posidonomya Becheri* Bronn, var. *siamensis* nov. × 1½.
8. *Pseudamusium* cf. *prætenue* (Von Koen.). × 1½.
9. *Aviculopecten* cf. *densistria* (Sandb.). × 2½.
10. *Athyris subtilita* Hall. × 1½.
11. *Camarophoria* sp. × 2.
12. Ditto. × 1½.
13. *Productus concentricus* Sarres-Kayser. × 3.
14. ,, *laripunctatus* Sarres. × 3.
15. *Chonetes* cf. *rectispina* Von Koen. × 2.
16. ,, aff. *buchiana* De Kon. × 2½.
17. *Proetus* cf. *coddonensis* Woodw. × 3.
18. *Phillipsia* aff. *silesiaca* Scupin. × 5.
19. *Cladochonus* cf. *Michelini* Edw. & Haime. × 1½.

REVIEWS.

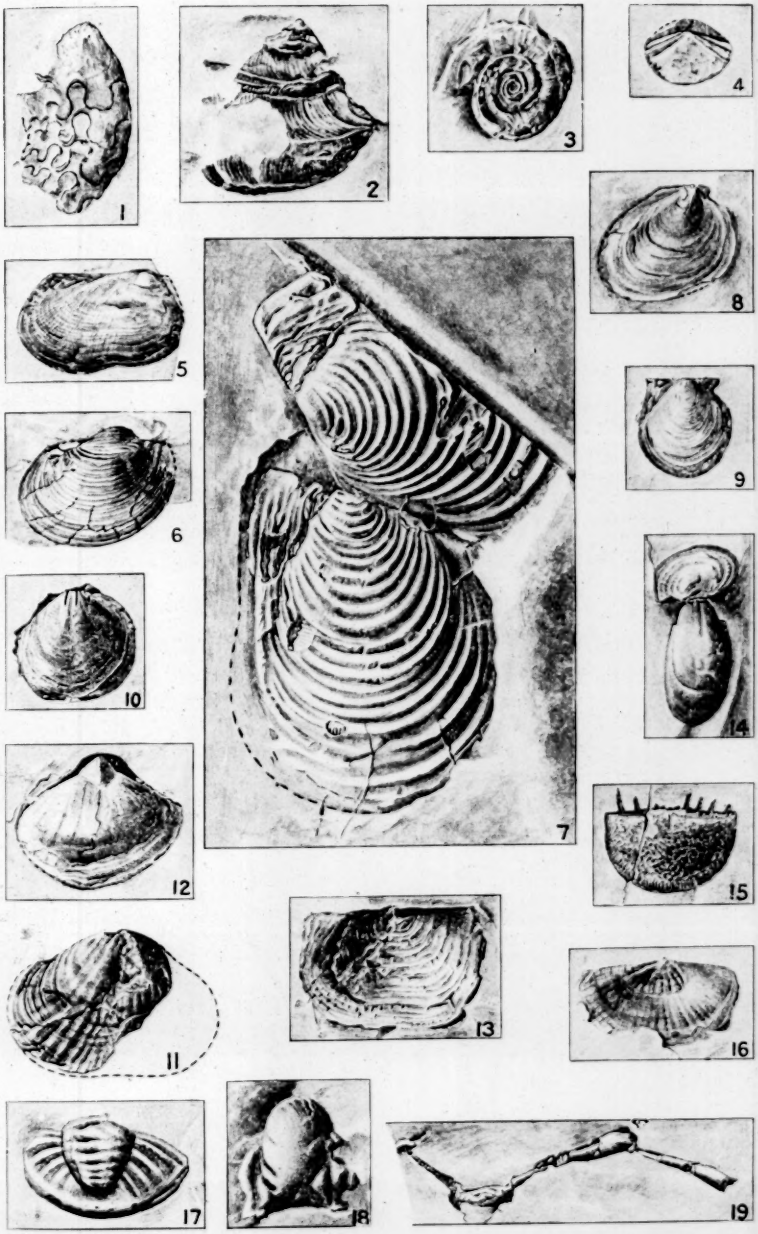
BLOCK MOUNTAINS IN NEW ZEALAND. By C. A. COTTON. Amer. Journ. Sci., vol. xliv, 1917, pp. 249–93.

THIS pamphlet deals more especially with the block mountains of Otago, a district in which the block features are unusually well preserved. The upland surfaces in Central and Eastern Otago have been described by both Park and Marshall as portions of a dislocated plain of erosion, termed a peneplain, the present relief being regarded as the work of erosion.

The writer's hypothesis, however, involves planation, sedimentation, and deformation, followed by a period of erosion, during which larger areas of the planed undermass have been re-exposed by stripping of the cover. It is quite possible that some of the eroded surface of the undermass has never been covered, and therefore forms a true peneplain; but, to the writer's mind, conclusive evidence as to the former wide extension of an overmass is afforded by the occasional preservation of small outliers of the cover on the upland plateaus; by wide distribution of the "sarsen stones" derived from the cemented quartz grit; and by the manner in which planed surfaces of the older rocks emerge from under brown coal strata as well as quartz grits with the same inclination.

Stress is laid on the fact that fault scarps form the boundaries of a number of blocks in Central Otago, and sufficient evidence of faulting is furnished by the attitude of the covering strata at the bases of the scarps. The conclusion arrived at is that the relief is very largely—almost entirely—due to recent differential movement of crust blocks.

H. V. S.



CARBONIFEROUS FOSSILS FROM SIAM.

TIN ORES, 1919. Monographs on Mineral Resources. By G. M. DAVIES. pp. 111. Imperial Institute. 3*s.* 6*d.* net.

THIS monograph is one of a series which is being issued by the Mineral Resources Committee of the Imperial Institute. It is only in recent years that geologists have taken more than a passing interest in economic geology, but with the increased attention paid to it by eminent scientists the subject has assumed an academic importance not hitherto known, and one may recall the early days when it was treated as a mere accessory to mining instruction. The result is that the literature of mineral economics has improved, and this monograph is an excellent example of the way in which such a monograph should be prepared. It maintains a just balance of treatment between the statistical and scientific aspects, a feature often lacking in economic papers. On the whole this monograph is rather more economic than geological, and in this we discern that there is a difference between "mineral resources" and "economic geology".

Although the occurrences of tin ore in the British Empire receive the chief attention, the foreign statistics and geology are adequately dealt with, while the exports and imports of different countries give an excellent idea of the tin trade as a whole. Some of the information is of transient interest only and need hardly have been embodied, e.g. the price of metallic tin in London.

To English geologists the most interesting original contribution is that of Professor Cronshaw, who describes the structures of the Cornish and Devon lodes at various places, and we quote a passage relating to the lodes of Camborne. "The mineral contents show a definite arrangement within the lode fissures, and, moreover, display well-defined mutual relationships. This definite arrangement is the outcome of a definite order of intrusion, which, for the Camborne district—and it very probably admits of a wider application—has been found to be as follows:—

I. Large-grained and considerably brecciated quartz.

II. Small-grained quartz, cassiterite, tourmaline, and chlorite.

III. (*a*) Brown, finely crystallized tourmaline and chlorite, or 'brown peach' with minute grains of cassiterite and a certain amount of arsenopyrite.

(*b*) 'Blue peach' with cassiterite and some arsenopyrite.

IV. (*a*) Fluorspar, and to a less extent, secondary quartz veins containing a little copper pyrites and occasional recrystallized cassiterite.

(*b*) Calcite veins.

(*c*) Veins of hæmatite, iron pyrites, quartz, etc.

(*d*) Veins of galena, zinc-blende, quartz, and copper pyrites.

The bulk of the cassiterite made its appearance in stage III (*a*)."

It is interesting to note that Professor Cronshaw confirms the view of apparent connexion between the cassiterite and the lead ores, as a similar sequence of mineralization has frequently been

noticed in other districts during the last decade. By early geologists this close genetic connexion was not credited, but its acceptance has led to the enunciation of theories which have yet to be developed on physico-chemical lines as a branch of the petrogenesis. There is no field of research which affords such scope for original work as the origin of lodes in their connexion with a consolidating magma, and particularly this question of the definite order of arrival of the minerals as an accessory function of it. As a whole the monograph is a complete treatise on the occurrence and production of tin ore as far as it is possible to make it in a few pages, and it is the best resumé of the subject yet published, the brief geological accounts being particularly good. D. A. MacAlister.

Marine Boring Animals Injurious to Submerged Structures. By W. T. Calman. British Museum (Natural History). Economic Series, No. 10. London, 1919. Price 1*s*.

THIS work, issued as a guide to an exhibit in the British Museum of the more important marine animals which are so destructive to timber and stone, will be of considerable interest to geologists.

Of the Molluscs which bore into wood a full and valuable account is given of the shipworm *Teredo navalis*, in which the boring is done by means of rows of fine sharp-pointed teeth on the front of the valves. Brief mention is made of other wood-boring lamellibranchs—*Pholas*, *Martesia*, *Xylophaga*. Next in importance to the shipworm as a destroyer of timber is the small Isopod Crustacean, known as the Gribble (*Limnoria lignorum*); other Crustacea which bore into wood are the Amphipod *Chelura terebrans* and the Isopod *Sphæroma terebrans*.

Animals which bore into rocks are more numerous than those which bore into wood, and include Sponges, Echinoderms, Worms, Molluscs, and Crustacea. *Pholas* is believed to make borings mainly by the rasping action of the shell which is provided with rows of spines or teeth towards the front edges. *Petricola pholadiformis*, although belonging to quite a different family (the Veneridæ), is remarkable for the close resemblance of its shell to *Pholas candida*. *Lithophaga* (*Lithodomus*) bores in calcareous rocks by chemical means, an acid secretion being formed by a gland in the mantle. *Saxicava rugosa* is found mainly in limestones, and the boring is probably effected by chemical means. The principal Crustacean which bores into rocks is the Isopod *Sphæroma quoyana*, found on the coasts of Australia and New Zealand, where it burrows in soft sandstone and claystone. Other rock-boring animals described are the Polychæte worm *Polydora* and the Sponge *Cliona celata*.

In connexion with rock-boring organisms attention may be called to a recent paper by Professor T. J. Jehu, dealing with the subject from the point of view of coast erosion (*Scottish Geogr. Journ.*, xxxiv, January, 1918).

HANDBOOK OF MINERALOGY, BLOWPIPE ANALYSIS, AND GEOMETRICAL CRYSTALLOGRAPHY. By G. MONTAGUE BUTLER, E.M., Director Arizona Bureau of Mines. pp. vi + 311, iv + 80, viii + 155. New York: Wiley & Son. 1918.

THIS book is in reality three books bound in one volume, each part being separately paged and having its own title-page and index. It professes to be a notebook for use in the field, and for this purpose the first two parts, on the physical characteristics of minerals and blowpipe analysis, are very well adapted; the book is small, and will go into a not very large pocket; the printing is clear, and the descriptions are short and to the point. The only exceptions that may be taken are to the photographic illustrations, which are on too small a scale to show to any advantage, and to the determinative tables, whose use, in their present form, seems rather cumbrous. In the last section, on crystallography, however, too much reliance has been placed on descriptions unaccompanied by figures, with consequent loss of clarity; and in addition the use of Naumann symbols, to the entire exclusion of the Miller system, would appear to be a mistake, in view of the very wide use of the latter system.

W. H. W.

THE PHOSPHATE DEPOSITS OF SOUTH AUSTRALIA. By R. LOCKHART JACK. pp. 136. Bull. No. 7, Parts i and ii. Geol. Survey of South Australia, 1919.

SOME idea of the importance of the South Australian phosphate deposits may be gathered from the fact that in 1916 only 2,042 tons of crude mineral phosphate were produced, of which 1,652 tons were valued, after grinding, at £3 12*s.* 7*d.* a ton. The total amount of phosphate rock produced by the Colony up to the end of 1918 is given as 89,456 tons, valued at £89,456. In addition to calcium phosphate rock, "large bodies of phosphate of alumina exist at St. John's," near Adelaide, but the material is not acceptable to the manufacturers of superphosphate, and the State regards it as worthless. Part i gives accounts of the natural occurrence and methods of dressing the material and preparing it for the market, as well as its use on South Australian land. Part ii consists of 90 pages devoted to "Reports on Individual Deposits", and contains many plans of workings and prospects and a few plates from photographs.

The following notes on the geological occurrence are taken from the Bulletin.

Guano.—With the exception of three places on the mainland, where cave-guano occurs, deposits of guano are only found on the islands or coasts, but these appear to have been worked out. The bulk of the material contained from 25 to 42 per cent of calcium phosphate. According to a report by the late F. R. George in 1902 a considerable quantity of guano was removed from an island in Coffin's Bay, where it was mixed with sand, broken sea-shells,

and vegetable matter, and in collecting this holes and cavities in the underlying limestones were followed down for the guano. At 10 feet phosphatic bone-breccias were encountered in the cavities.

Rock-phosphate.—The deposits of the mainland are found in association with metamorphosed Cambrian or pre-Cambrian limestones or in the adjacent argillaceous sediments. The author is in some doubt as to whether the phosphate with which the limestones are associated is a contemporaneous deposit, concentrated by the withdrawal of calcium carbonate in solution from phosphatic limestone, or whether the phosphate has been introduced from some extraneous source at a later date as a metasomatic replacement of the marmorized limestones and calcareous slate. "In their location among the steeply inclined sedimentary beds the bodies are generally close to the limestones . . . but others are found in clay-filled pockets in the strike of the limestone beds. Their position suggests derivation from the eroded portions of the limestones, and that precipitation of the phosphate by replacement took place either on the remaining limestone or in calcareous slate from which the bulk of the carbonate has been removed, the resulting rock being a phosphate with a high insoluble content. Metasomatic replacement is indicated by the presence of older veins of quartz, surrounded by phosphate . . . Another feature indicating metasomatism is the silicification of certain beds at some of the deposits to form a chert-like black to brownish-yellow rock containing a little phosphate," which is "frequently brecciated and contorted in places, and is found embedded in the phosphate rock. White to greenish sub-translucent, stalactitic, reniform, and mammillary phosphate is common, occurring as coatings of vughs, and wholly or partly surrounding masses of rock-phosphate, and is clearly secondary to the main mass of the rock in its order of deposition. Both limonite and manganese oxide are almost invariably associated with the phosphate rock. It is probable that in the replacement and solution of the rock containing the phosphate deposits, the iron set free has a tendency to segregate at the surface." This theory indicates subsequent replacement, and the author goes on to describe the close association of the deposits as a whole with Tertiary gravels which overlie the deposits. Where the latter have been eroded the deposits of phosphate do not exist. He associates the process of metasomatism with pre-Tertiary drainage, and the destruction of all the previously existing deposits not protected by the Tertiary gravels to post-Tertiary denudation. This implies that the deposits do not extend to great depth, but they have been proved to depths of 110 feet. He points out the absence of any evidence as to the true age of the phosphatization.

Apatite.—This occurs at Moonta, Wallaroo, and Balmacoota, in pegmatites of "pre-Cambrian age". In a vein near Balmacoota Spring the apatite makes up 40 per cent of two veins aggregating 5 feet in thickness.

The absence of proper petrographical examination detracts somewhat from the value of the Bulletin as a contribution to science, but no doubt it will prove of value to prospectors in South Australia.

Preliminary Report on the Geology of the Country West of Sinoia, Lomagundi District. By A. J. C. Molyneux, F.G.S. Southern Rhodesia Geological Survey, Bulletin No. 6. pp. 47, with a folding sketch-map. Salisbury, 1919.

THIS memoir contains a preliminary account of the geology of an area in Northern Mashonaland, including the greater part of the "copper belt" of that region. It is interesting as revealing the existence of some 34,000 feet of stratified rocks, apparently unrepresented in Southern Rhodesia, but possibly correlative with the Transvaal or Potchefstroom System of the Union. The south-eastern portion of the area is occupied by crystalline schists, mainly of igneous origin, but including a belt of banded ironstone, probably sediments interbedded with the lavas. The gold-bearing rock, commonly known as the Eldorado conglomerate, is of uncertain origin, and the application of the term "banket" to it is deprecated, as it has no features in common with the Rand bankets. The overlying sedimentary rocks, which it is proposed to call the Lomagundi System, comprise fragmental and chemical deposits, including conglomerate, arkose, sandstone, shale, slate, limestone, and the Sinoia Cave dolomite group. The most important member is the uppermost or Piriwiri series, which attains a thickness of over 20,000 feet. The Piriwiri mineral belt, which is about 18 miles long and now worked to a considerable extent, carries gold and copper, the most important occurrence being the Eldorado mine, whose output to date has been about 432,000 ounces of gold. R. H. R.

The Genesis of the Ores at Tonopah, Nevada. By E. S. Bastin and F. B. Laney. U.S.G.S. Prof. Paper 104. pp. 50, with xvi plates and 22 text-figures. Washington, 1918.

THIS is an elaborate study illustrated by beautiful plates and figures of the genesis and relations of the ores of the well-known silver-producing mining area of Tonopah, Nevada. The author's conclusions, largely based on microscopic examination of polished sections, may be summarized as follows: the great bulk of the silver ores are of primary origin, but two types of primary minerals are recognized. The alpha-hypogene group have remained exactly as they were first deposited, including galena, blende, chalcopyrite, arsenopyrite, pyrargyrite, polybasite, argentite, wolframite, and electrum, with, probably, stephanite and argyrodite. The beta-hypogene minerals are those that have been formed by replacement of the alpha group during the primary mineralization, and comprise argentite, polybasite, chalcopyrite, and electrum. The minerals

formed by oxidation and *supergene* enrichment are native gold and silver, argentite, polybasite, pyrargyrite, silver haloids, malachite, zinc silicate, with carbonates, quartz, chalcedony, barytes, gypsum, etc. An interesting feature is the evidence that has been found of the existence of one or more ancient periods of denudation and oxidation, at horizons now buried under subsequent deposits. The ore-veins are regarded as replacements of the volcanic country rock, now called the Mispah trachyte, and extending down into the underlying rhyolitic series, both being of Tertiary age. In many places the geological evidence is favourable to the persistence of rich primary silver ores to depths considerably greater than any yet reached, though hot ascending waters in the deeper workings may prove troublesome. It may be noted that the occurrence of such minerals as pyrargyrite, polybasite, and stephanite in a primary zone is unusual.

While not pretending to a high standard of culture in dead languages, the reviewer ventures to enter a vigorous protest against the employment of such a barbarism as the word "supergene", half Latin and half Greek. This is on a par with that journalistic horror, "hypersensitive." Surely Anglo-Saxon, or, at worst, good Latin terms can be found for such a simple idea as is here implied. What is the matter with "secondary"? R. H. R.

Suess as Palæontologist.

IN the number of the *Revue Critique de Paléozoologie* for January–April, 1919, which has just come to hand, M. G. F. Dollfus has an excellent article on the completion of the French edition of *Das Antlitz der Erde*. In it he discusses the palæontological work of Suess, and shows how it gradually led him on to those wider tectonic studies for which, indeed, it formed the evidence and the foundation.

It may be mentioned that the price of M. Cossmann's useful *Revue* has been raised to 12 francs per annum.

South Australia Department of Mines, Mining Review No. 30. pp. 56. Adelaide, 1919.

THIS report contains statistics concerning the mining industry of the State for the half-year ending June 30, 1919, and a number of special reports on points of interest. The most noteworthy feature of the period under review was the dislocation of the copper industry, leading to the cessation of smelting at Wallaroo, and almost complete stoppage of production. The development of resources of non-metals continues to progress, and reports are printed on deposits of barytes, whiting, graphite, and asbestos. The production of iron ore at Iron Knob has now reached the satisfactory figure of about 1,000 tons per day. The body of manganiferous iron ore is now exposed in two open workings to a depth of 100 feet, and the reserves are evidently very large. An interesting

account is given of work carried out by the Wallaroo and Moonta Mining and Smelting Company, Ltd., for the welfare of their employees, which is of a most elaborate and well-organized nature, and conditions there appear to be ideal.

The Classification of the Plagioclase-nepheline Granitoid Rocks. By A. Lacroix. *Comptes Rendus*, t. 170, 1920, p. 20.

THE terms *essexite* and *theralite* have suffered somewhat from lack of definition and discrimination in their use. Rosenbusch suggested the term *theralite* for plagioclase-nepheline rocks of plutonic habit, and chose as the original type a rock from the Crazy Mountains, Montana, in which plagioclase was stated to be present. This was a mistake, as the rock proved to be a shonkinite, and recognizing this Rosenbusch afterwards took the unequivocal theralite of Duppau, Bohemia, as the type example. Lacroix, however, proposed in 1902 to use theralite for melanocratic alkali-syenites. He admits that with other petrologists he has applied the term inconsistently, and in an instructive paper he now attempts to put this group of rocks in order once and for all.

The term *theralite* he reserves for mesocratic rocks which differ from essexites in having a smaller proportion of potash-felspars (often reduced to a mantle bordering the plagioclase crystals), and in general a higher ratio of nepheline to felspars. In essexites, as in the type-rock of Salem Neck, there is a notable quantity of orthoclase or soda-orthoclase ; interstitial nepheline may be present, and hornblende is a constant ferromagnesian constituent.

From the theralites proper Lacroix separates two types in which the nepheline-felspar ratio is lower and the plagioclase more calcic than in the normal members of the group. *Luscladite*, one of these types, is characterized by the general absence of hornblende and the presence of olivine and often of biotite. The Crawfordjohn essexite is a British example, and Tyrrell's *kylite* is regarded as a melanocratic facies. The other type, *berondrite*, is characterized by the presence of elongated crystals of brown hornblende associated with titaniferous augite. The *montrealite* of Mont-Royal is a coarse-grained melanocratic variety. Theralitic rocks less rich in alkalies than those already mentioned are the *mareugites*, which are further characterized by hauyne, and which vary from highly felspathic to almost holomelanocratic types.

Two rocks are considered as heteromorphic forms of berondrite, since they differ essentially from the latter in mineral composition but not in chemical composition. In *mafraïte* nepheline fails to appear, its constituents being present in an aluminous soda-amphibole. In *fasinite* titaniferous augite contains the missing mineral, which in this case is plagioclase. Fasinite, though composed essentially of titaniferous augite and nepheline, thus differs from ijolite in containing abundant normative plagioclase. *Bekinkinite* is not dissimilar in chemical composition from fasinite

except in its greater content of water. The minerals, however, are mainly hornblende and analcite.

Corresponding to the soda-series considered above, few leucite rocks are known, the granitoid types so far recognized being restricted to certain ejected blocks from the tuffs of Monte Somma. *Puglianite* is mainly composed of leucite, anorthite, and augite, and is the homologue of mareugite. A heteromorphic form of puglianite, known as *sebastianite*, is mainly composed of biotite, anorthite, and augite, and corresponds to mafraïte in the soda series.

The paper concludes with a series of thirty-three analyses, including several which appear for the first time.

ARTHUR HOLMES.

REPORTS AND PROCEEDINGS.

EDINBURGH GEOLOGICAL SOCIETY.

February 18, 1920.—Mr. E. B. Bailey, M.C., B.A., F.G.S., F.R.S.E., President, in the chair.

"On the Vascular Plants of the Chert Band of Rhynie, Aberdeenshire." By Dr. Kidston, LL.D., F.R.S., President of the Glasgow Geological Society.

The remains of four vascular plants have been discovered in the silicified peat bed at Rhynie, Aberdeenshire. These are—*Rhynia major* K. & L., *R. Gwynne-Vaughani* K. & L., *Hornea Lignieri* K. & L., and *Asteroxylon Mackiei* K. & L. Though their remains occur in more or less fragmentary condition, it has been possible, in the case of the first three, to obtain an almost complete knowledge of their morphology and anatomy. In regard to *Asteroxylon Mackiei* the vegetative region is known with considerable fullness, but the sporangia, which we believe to belong to this species, have not been found in organic connexion with its stem or branches, so there is an element of doubt on its fertile condition. All these vascular plants appear to have grown in a gregarious manner. A brief description of each may now be given.

Rhynia major was rootless and had no leaves. It consisted of a system of dichotomously branched cylindrical stems, which arose from underground branched rhizomes, that were attached to the peaty soil by numerous non-septate rhizoids. The plant was larger than *R. Gwynne-Vaughani*, and probably attained a height of 40–50 cm. There is, however, no clear information on this point.

The rhizome is composed of delicate tissue with a vascular bundle which dichotomized, and some of its branches grew upwards as tapering aerial stems. The stem bore no leaves or lateral projections. It consisted of a wide cortex composed of a narrow outer, and a wide, more delicate, inner zone. The vascular system consisted of a simple cylindrical stele, formed of a solid strand of tracheides, with no distinction of protoxylem and metaxylem. Surrounding the xylem was a broad zone of phloem.

The plant bore large cylindrical sporangia with thick walls, and contained numerous spores of one kind developed in tetrads.

Rhynia Gwynne-Vaughani was also rootless and leafless, and very similar in morphology and anatomy to *R. major*, but was a smaller species, probably not more than 20 cm. in height. It differed from *R. major* in having small hemispherical protuberances derived from the superficial tissues of the stem. These might remain as small protuberances, or develop rhizoids. Sometimes in place of the protuberances adventitious branches were produced, or bulbil-like growths attached by a narrow base that probably served for vegetative reproduction. The sporangia were of similar structure to those of *R. major*, but much smaller, and contained numerous spores of one kind.

Hornea Lignieri was a small rootless and leafless plant, whose stems branched dichotomously, and attained a diameter of 2 mm. They arose from a branched rhizome which had no vascular strand of its own. The stele of the stem consisted of a central cylinder of xylem, with smaller central and larger peripheral tracheides surrounded by a zone of phloem. The thickening on the tracheide walls is in the form of irregularly connected rings or a spiral. The stem has a well-defined cuticle and epidermis, but the cortical tissues are not clearly distinguishable into inner and outer zones. The cortex is usually very imperfectly preserved.

The sporangial cavity of the indehiscent sporangium is enclosed by a fairly thick wall, and had a sterile column of tissue or columella projecting so far from the base that the actual spore cavity is dome-shaped. The sporangia arose by the transformation of the tips of certain branches. The numerous spores are of one kind.

Asteroxylon Mackiei was a larger and more complex plant than any of the others. The stems arose from rhizomes without absorbent hairs. They attained a diameter of 5 mm. Some of the rhizome branches bent upwards and developed into leafy stems. The rhizomes have an epidermis with outer and inner cortex, and a cylindrical strand of xylem surrounded by a zone of phloem. The transition area between the rhizome and stem bears stomata and scale-leaves, and the xylem gradually assumes the stellate form of the stem xylem. The stem has a cuticle, epidermis with stomata, outer and inner cortex—the latter usually being separable into three zones—an outer, middle trabecular, and inner zone. The stele consists of a stellate strand of xylem enclosed in a zone of a phloem. The tracheides of both rhizome and stem have a prominent spiral thickening. The stem bears numerous simple leaves about 5 mm. long without any vascular bundle in the free portion, the leaf-trace stopping at the enlarged leaf-base. The free portion of the leaf is oval in transverse section.

The probable fertile region consisted of slender branched leafless axes and pearshaped sporangia about 1 mm. long, with regular apical dehiscence. Homosporous. Spores developed into tetrads.

Mineralogical Society.

January 20, 1920.—Dr. A. E. H. Tutton, F.R.S., Past President, in the chair.

Dr. E. S. Simpson: "Gearksutite at Gingin, Western Australia." The mineral, which occurs in Cretaceous greensand, is considered to have a composition corresponding to the formula $CaF_2 . AlF(OH)_2 . H_2O$, and to have originated from the interaction in situ of fluorapatite, gibbsite, and carbonated water.—C. E. Barrs: "Fibroferrite from Cyprus." Analysis of material from Skouriotissa, Cyprus, gave the following result: Fe_2O_3 31·36, SO_3 30·95, H_2O (by difference) 37·01, insoluble 0·68.—Dr. G. T. Prior: "On the Classification of Meteorites." For purposes of the classification of meteorites the significance is pointed out of the chemical composition of the nickel-iron and the magnesium silicates. In the case of meteoric irons the structural features, as revealed by etching, are shown to be closely related to the content of nickel. In meteoric stones the proportion of magnesia to ferrous oxide in the magnesium silicates varies directly with the proportion of iron to nickel in the nickel-iron. On these principles the four classes of meteorites, viz. irons, stony-irons, chondrites, and achondrites, can be divided into inter-related groups. The three groups of chondrites are distinguished as enstatite-chondrites, bronzite-chondrites, and hypersthene-chondrites, according to the chemical composition of the pyroxene. The achondrites are divided into corresponding groups of enstatite-achondrites, bronzite(-augite)-achondrites, and hypersthene-achondrites, while a fourth group is added richer in lime (and mostly also in alumina) than the chondrites. To avoid confusion owing to Brezina's misuse of the term chladnite, the enstatite-achondrites, comprising Aubres, Bustee, and Bishopville, are called Aubrites, while for the hypersthene-achondrites (Shalka, etc.) a reversion is made to Tschermak's original name of diogenite.—A. F. Hallimond: "On Torbernite." In continuation of the author's previous work a series of weighings were made on Gunnislake material held over various concentrations of sulphuric acid. Dehydration did not occur at the pressure required, and only took place slowly over strong acid in a period of many months. It is clear that this mineral cannot be identical with ordinary torbernite. The refractive index agrees with that found for an abnormal torbernite by N. L. Bowen. Normal torbernite has the density 3·22 and mean index 1·585, while for artificial metatorbernite and for the Gunnislake mineral the density is 3·68 and the index 1·624. An approximate reading yielded for Gunnislake crystals $c : a = 2·28 : 1$. The basal planes of the two forms are of the same dimension and the volume change due to the addition of $4H_2O$ is borne by an increase in the vertical axis. The density of the water of crystallization is 1·2, a value common in hydrated salts, while the refractive power is equal to that for liquid water.

Geologists' Association.

January 2, 1920.

"The Liassic Rocks of the Cardiff District." By A. E. Trueman, D.Sc., F.G.S.

The greater part of South Glamorganshire, from Cardiff westwards to beyond Bridgend, consists of Lower Liassic rocks (Hettangian and Lower Sinemurian), which are well seen in some 20 miles of magnificent cliff sections. Only meagre descriptions of these rocks have been hitherto published. A detailed study has been undertaken, first because nowhere else in this country are such continuous sections of these rocks available, and secondly because the normal deposits consisting of limestones and shales seen near Cardiff, when traced westwards, pass into littoral facies or massive limestones and conglomerates. In the present communication an account of the normal Liassic rocks of the Cardiff district is given, as this will form a basis for the correlation of the modified deposits further west.

The Liassic rocks near Cardiff occur in several outliers, the chief being those at Penarth, Lavernock, Leckwith, and St. Fagans; the sequence in the two former is clearly seen in cliff sections, and in those localities there exists an almost complete transition from Keuper to Lower Lias, so that they have become classical localities for the study of the Rhætic beds. In the cliffs at Lavernock, where the Liassic sequence has been most fully examined, the rocks are seen to form a gentle syncline, and since many of the limestone bands form extensive reefs on the beach it is an easy matter to collect fossils in place.

The general sequence at Lavernock and in the neighbouring outliers is as follows:—

	Feet.
Nodular limestones and shales, mainly *angulatus* zone, about	40
Lavernock Shales, *angulatus* zone, with *Waehneroceras* in the lower portion . . . . . ,,	40
Nodular limestones and shales with *Caloceras* cf. *Johnstoni* . . . . . ,,	18
Limestones and shales with *Psiloceras* cf. *planorbe* . ,,	5
Limestones and shales (*Ostrea* beds) . . . . ,,	21
White Lias . . . . . ,,	9

Liverpool Geological Society.

February 10, 1920.—Mr. W. T. Walker, B.Sc., F.G.S., President, in the chair.

The following paper was read: "Dumb-bell Islands and Peninsulas on the Coast of South China." By Walter Schofield, M.A.

The paper records observations made during a residence of several years in Hong-Kong, in the neighbourhood of which the "dumb-bell" island and peninsula—a physical feature of the coast of South China which attracts attention by its frequency—are especially common.

A "dumb-bell" may be defined as two land areas connected

by a relatively narrow isthmus of sand which is never below high-water mark in any part of its length. The size of the areas of land may vary to any extent, but the highest points in both must rise higher above sea-level than any part of the isthmus. The best example is that known to English residents in Hong-Kong as Dumb-bell Island, which consists of two granite hills, each about 300 feet high and $1\frac{1}{4}$ miles long, connected by a low sandy isthmus 170 yards wide, rising 10 feet above normal high-water mark. The Portuguese colony of Macao is, perhaps, the most typical example of a dumb-bell peninsula.

There are several varieties of dumb-bell islands, and their origin is ascribed by Mr. Schofield to (1) decay of rocks, (2) partial submergence of the land, (3) rainstorms, (4) destruction of vegetation, (5) marine action, and these causes are examined and explained in detail. Nearly all the dumb-bell islands and peninsulas are composed of granite, generally partly decayed, and their evolution can be followed through all its stages in the examples near Hong-Kong. The paper concludes with a list of the islands and peninsulas of this type near Hong-Kong, to the number of forty-six.

CORRESPONDENCE.

THE SGÙRR OF EIGG.

Sir,—I have no wish to enter into a controversy upon the subject of the Sgùrr of Eigg with Dr. Harker, whose letter, I may be pardoned for suggesting, savours rather more of the "Don" than of the "Survey man". I may remark, however, that I have read Dr. Harker's paper carefully, and did not find it convincing. The occurrence of granite pebbles in the conglomerate may not be new now; I believe it was new when Mr. A. S. Reid and I made the discovery—in 1898. I have never seen any of the older granite fragments that Dr. Harker mentions, the granites "that are not exposed at the surface"; possibly they may be of Old Red Sandstone age. The granite pebbles we discovered in the conglomerate are certainly not of Old Red Sandstone age. In any case, this point concerning granite pebbles is arguable, but is not vital.

The question at issue between Dr. Harker and myself is something much more important, namely, the relative values of theoretical and field evidence. I bow to Dr. Harker's knowledge of microscopic petrology, but in matters of field evidence each man must rely on his own observation. It is possible to argue at any length about possibilities, probabilities, and theoretical matters, but there should be no possible mistake about facts as observed in the field. I cordially agree with Dr. Harker that a little knowledge is dangerous, but, on the other hand, assurance as to facts is very safe. Anyone who has a lengthy experience of economic geology—the kind of geological work that is practically useful, as distinguished from that which

is more purely academic—will realize that absolute assurance as to facts in field evidence is essential. Less than absolute assurance may be interesting but is economically useless.

Dr. Harker and I, from our respective experiences in various parts of the world, obviously take different points of view, and therefore I suppose must agree to differ upon this problem of the Sgùrr of Eigg.

E. H. Cunningham-Craig.

The Dutch House, Beaconsfield.
March 1, 1920.

[The foregoing letter was submitted to Dr. Harker in MS.; his reply is printed below.—Ed. Geol. Mag.]

Sir,—I am sorry if the tone of my former note on this subject was unsuitable. It is no doubt a Don's failing to dislike being patronized, even by an old student.

I should not trouble you again were it not that Mr. Cunningham-Craig persists in representing that I stand for "theory" while he is the champion of "field evidence". I must point out once more that my theory was the same as his until I came to survey the ground, when the field evidence compelled me to a different interpretation. There was no question of "microscopic petrology" until Mr. Craig introduced it, when he claimed to decide that the granite fragments in the Eigg agglomerate are of a Tertiary, not a Palæozoic type. It seems that, despite his compliments, he will not allow me the same privilege in respect of the granite fragments in Skye and elsewhere. His experience in many parts of the world may be, like Sam Weller's knowledge of London, extensive and peculiar, but does not seem to have much bearing upon this specific point.

Alfred Harker.

PALÆONTOLOGICAL ABSTRACTS.

Sir,—Probably most of your readers are by this time aware that the Société Géologique de Belgique has undertaken to publish a "Review of Geology and Connected Sciences", consisting of summaries of recent papers written, so far as possible, by the authors themselves. Further information may be obtained from the Secretary to the Review, Laboratoire de Géologie, Université de Liége.

The object of this letter is to inform British Palæontologists that the new Review, instead of competing with *La Revue critique de Paléozoologie*, which M. Cossmann has been bravely conducting for over twenty years, will take it into collaboration, leaving the direction in the hands of M. Cossmann. All writers on Palæozoology in this country are therefore asked to be good enough to send M. Maurice Cossmann, 110 Faubourg Poissonière, Paris, Xe., separate copies of their papers, or if that be impossible, at least the title and bibliographic details of each publication.

F. A. Bather.